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# PROCEEDINGS OF

# THE LINNEAN SOCIETY OF LONDON

152nd Session (1939–40) Part 1

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PROCEEDINGS OF

# THE LINNEAN SOCIETY OF LONDON

152nd Session (1939–40) Part 1

## PROCEEDINGS OF THE GENERAL MEETING
### 26 October 1939

Mr. J. Ramsbottom, O.B.E., Dr.Sc., President, in the Chair.

The Proceedings of the Anniversary Meeting held on Wednesday, 24 May 1939, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

Certificates of recommendation of the following candidates for Fellowship were read :—For the first time, in favour of Richard Charles L'Estrange Burges, William Leslie Carter, David Noel Jones, Walter Eric James, and Mary Rebekah Lambert.

The President made the following statement,—

It is unnecessary for me to comment on the present regrettable international situation.

As you know your Council had in mind the possibility of being faced with it, and the steps already taken before May last to protect the Society's treasures have been reported ; the Linnaean Collections (specimens and books) were moved, and the medals and other valuables from the Iron Chest. Since the outbreak of hostilities the Smithian Herbarium and some smaller collections have been moved and stored in what we hope is a safe place ; we are indebted to the Director of the British Museum (Natural History) for his help in this matter.

So much for the collections. With regard to the premises, we have taken what air-raid precautions seemed called for. Certain pictures, busts, and other material have been stored in a way which would prevent damage except by a direct hit. The basement has been rearranged to form a refuge for the Staff.

Much careful thought has been given to the desirability of moving the headquarters of the Society. It is the unanimous decision of the Council that the Society should carry out its

normal activities so far as is possible. This is in the best interest of Fellows, of the Society, and of the subjects in which the Society is interested. Apart from the communications at meetings it is absolutely essential that biologists should have an opportunity for informal meeting at some central place in London, and we are of the opinion that the Society will be doing a work of national importance by keeping its rooms open and allowing them to be used by other Societies or bodies of biologists who are in need of such a meeting place either for formal or informal discussions.

In 1914 the time of meeting was altered from 7 o'clock to 5 o'clock. Moonlight nights had been favoured in the early days of the Society, before streets were properly lighted. Now, because of the black-out, it is necessary to hold our meetings earlier. The next meeting will be held at 2.30 p.m. and the following, summer-time being ended, at 2.15 p.m. Experience will guide us as to the arrangements to be made after Christmas.

We are not able to offer shelter within the building if an air-raid warning be given. This is a small matter, however, as there is abundant shelter in the immediate neighbourhood. A plan is on the table.

One further point—Times are bad financially, and for many will doubtless get worse. The Council is determined that The Linnean Society of London shall do its utmost not only to fulfil its duties to its Fellows but to play whatever part it can in the present national emergency: the Linnean Society has the obligation of its eminence and its history. As one sign of our attitude I may point out that it has been decided not to move any books, however valuable, from the Library: the Linnaean library has gone—everything else remains for consultation.

May I suggest that no Fellow should regard the Fellowship as a luxury, but as something to be continued if at all possible. Perhaps some Fellow may be more fortunate than the majority and be faced with the prospect of excess profits. If so, I am sure our Treasurer will be able to suggest a way in which some of these may be applied to a charity—for many need the solace that a study of nature brings.

I trust that the steps taken by the Council have your approval.

The President reported the deaths of Dame Maria Ogilvie Gordon, Dr. A. H. Trow, Mr. C. H. Bestow, Professor R. S. Troup, Mr. J. A. Hill, and Mr. E. A. Bunyard, Fellows of the Society.

Mr. H. W. Parker read a paper, illustrated with lantern-slides, on 'Luminous organs in Lizards'. [This Paper has been published in the Journal—Zoology.]

*Abstract.*—

In a collection made recently in Trinidad by Mr. Ivan Sanderson were the first known male examples of the Teiid lizard *Proctoporus shrevei* Parker. This sex is characterized by a series of large, black, lateral spots each with a small, glistening white centre. The colour of this central spot is not due to pigment, but to the structure of the skin. The epidermis is reduced to less than half its normal thickness, and the chromatophore layer is absent. In its place is a thick pad of transparent spongy tissue with large inter- or intracellular spaces. There are no other apparent modifications and no indications of special nerve-endings or an increased blood supply. The association of a transparent centre, surrounded by dense, opaque pigment suggested a connexion with light, possibly as a simple light-emitting organ. Mr. Sanderson reports that under certain circumstances, notably when stimulated by the flashes of an electric torch, the spots actually appeared to be luminous.

The organs show no similarity of structure with those organs which in other groups are known to generate light, but it is possible that they may function like the so-called luminous paints, or be highly efficient light reflectors like the ' Reflection Pearls ' of certain nestling birds.

*Discussion.*—

Dr. W. T. CALMAN pointed out how great an interest luminous organs command when they are in terrestrial animals. He could recall no other instance, except among insects.

Dr. G. P. BIDDER would like Dr. Calman to tell the meeting whether it is now still held that the shining in the dark of the eyes of carnivora is entirely due to reflection from the tapetum.

Mr. M. A. C. HINTON recalled that the collector, who had been working with an electric torch, said the luminosity finished after he had extinguished his torch.

Mr. W. S. ROWNTREE drew attention to the fact stated in the paper that the luminous areas were confined to the male : and to suggest that that seemed somewhat contrary to what is usual. He further queried whether the lizards are nocturnal in their habits.

The PRESIDENT remarked that whereas in most animals luminosity when it occurs appears to be located in definite organs there are no such organs in those fungi which are luminous. Here the emission of light is much more diffuse, though it may be restricted to the mycelium, for example, or the gills.

Prof. T. M. HARRIS gave an account of his paper, ' A contribution to the knowledge of the British Freshwater Dinoflagellata '. [Printed in full, p. 4.]

Mr. M. A. C. Hinton, in the absence of the author, gave an account of Mr. J. E. Hamilton's paper, 'On the history of the Elephant Seal, *Mirounga leonina* (Linn.)'. [Printed in full, p. 33.]

The following papers were read in title :

'The Skull of *Acontias meleagris*, with a study of the affinities between Lizards and Snakes.' By Dr. G. T. Brock. (Communicated by Prof. E. S. Goodrich, F.R.S., F.L.S.) [This Paper will be printed in the Journal, Zoology.]

'A new Apodal Lizard from Ceylon.' By P. E. P. Deraniyagala, M.A., F.L.S. [Printed in full, p. 37.]

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## A CONTRIBUTION TO THE KNOWLEDGE OF THE BRITISH FRESHWATER DINOFLAGELLATA.

By T. M. Harris, F.L.S., University of Reading.

The Flagellates make up one of the least-known sections of of the British Flora (or Fauna) ; how ill known they are is shown by the fact that every pond or ditch which I have studied at all closely has yielded at least one and often many new forms. The present paper is one of a series which I hope to contribute on these organisms.

All the species described here were collected within a few miles of Reading, many in the grounds of the University. It will be seen that just over half the species are new to science, and three-quarters are new to Britain, but there is no reason to suppose that this district is particularly rich—certainly it is less rich than the Lake District.

*Ecology.*—The waters of the Reading district fall into two classes : eutrophic waters among arable or grazing land and oligotrophic waters on heath land. Both classes include small lakes, ponds of various sizes, and small ditches ; there are also rivers and drinking troughs with eutrophic water.

In general, it may be said that eutrophic waters provide large kinds of *Peridinium*, *Glenodinium*, and if rich in nannoplankton will occasionally provide holozoic Gymnodiniaceae, while oligotrophic waters provide certain small kinds of *Peridinium*, *Glenodinium*, and certain other Gymnodiniaceae, especially *G. impar*. Eutrophic ponds with abundant rotting leaves provide various saprophytes and a characteristic Dinoflagellate, *Glenodinium helicozoster*.

It is a curious fact that there is very little general difference between the flora of permanent ponds and those which dry

up every summer. Another peculiar fact is that a characteristic and uncommon species will reappear year after year in a particular pond. It has, therefore, seemed worth while to record precise localities.

*Classification.*—The Dinoflagellata are very largely marine ; the freshwater species being relatively few, confined to certain of the very numerous families, and among the least highly organized of these families : there are nevertheless a good many kinds.

Schiller (1933, 1937), in treating the freshwater forms along with the marine ones, gives a classification which is rather elaborate ; for the freshwater forms alone the simple scheme of Fritsch (1932) serves well. He divides them into the ' Gymnodiniaceae ', consisting of naked to lightly walled forms, like *Glenodinium*, and the ' Peridiniaceae ', consisting of forms with a wall made up of easily discernible plates. To the Gymnodiniaceae might be associated the Phytodineaceae, in which the organism is for part of its life like a *Gymnodinium* and for part a non-motile cell of peculiar form.

I have found the greatest difficulty in discriminating between *Gymnodinium* and *Glenodinium* species ; and further—no doubt through faulty technique—have not succeeded in making out the plating structure of any *Glenodinium* with the necessary degree of completeness and certainty. No adequate treatment of the very numerous and varied species of the *Glenodinium pulviscus* group has been possible, and no attempt has been made to follow Schiller (1937) in his division of this order into a number of different families on plate arrangement.

*Technique.*—The reason why the unarmoured Dinoflagellata have been comparatively neglected is that they are difficult to observe ; in dying they liquefy and in life they move too fast to see clearly. A simple method of immobilizing the live specimen, which so far as I know is new, is to place it in a hypertonic solution of any non-toxic material; sugar was the best of those tried. Sugar solution is simply placed at the side of the cover-slip and it is allowed to diffuse in. As the flagellate swims it comes into a diluted solution where it struggles feebly and then becomes inactive, but with the flagellum extended. As the solution becomes stronger the protoplasm shrinks ; but this occurs chiefly in the furrows, thus accentuating surface features and often considerably facilitating their observation. The cell may remain alive for a long time—often as long as an hour in this solution. It should be pointed out that this method, though giving good results with certain marine Dinoflagellata, is not applicable to all flagellates, as in Chrysomonads it causes drastic change of form.

It is often very difficult to decide whether a dinoflagellate has a distinct wall; by the methods indicated below various grades of wall development were distinguished :—

1. On death the cell breaks up explosively.
2. On death it becomes spherical, but does not dissolve in water, though it does in dilute KOH.
3. The cell has a rigid periplast which shrinks with the protoplasm on plasmolysis; it is rigid enough for the cell to retain its form to some extent when dead, but it is softened by KOH.

   The above types are included in *Gymnodinium*, *Amphidinium*, or *Massartia*.

4. The cell has a delicate wall from which the protoplasm shrinks in hypertonic solution. The wall is not dissolved by cold dilute KOH, but may be by sodium hypochlorite or warm KOH.
5. As 4, but the wall is thicker and can be freed from protoplasm by warm KOH or by NaOCl.

   4 and 5 are found in typical species of *Glenodinium*; also in *Hemidinium*.

6. The wall is thicker, and when freed from protoplasm shows obvious plates. It resists NaOH and NaOCl, though the plates are apt to come apart.

   *Peridinium*, *Ceratium*.

The chief difficulty arises in discriminating between a rigid periplast (3) and a very thin wall (4), for in some species of *Glenodinium* certain individuals show a wall on plasmolysis and others do not. For this reason, the generic classification adopted here has not been completely consistent with this scheme, *Glenodinium limos* with a very rigid periplast being placed in that genus instead of in *Gymnodinium*.

In the *Gymnodinium* group the genera are distinguished by their form, *Amphidinium* having a girdle near the apex, *Gymnodinium* round the middle, *Massartia* near the antapex, and *Gyrodinium* markedly spiral. The last genus to a great extent overlaps the other three, and, though not used here, it is possible that certain of the species would have been better placed in it. In each of these genera and in *Glenodinium* the species are divided into those with and those without chromatophores.

## The genus Gymnodinium Stein.

### Group A.—*Colourless holozoic species.*

1. **Gymnodinium blax,** sp. nov. (Fig. 1, A–F.) *Cellula* ovalis, parum dorsiventraliter compressa : epiconus hypoconum aequans, vel paulum major, rotundus vel obtusus :

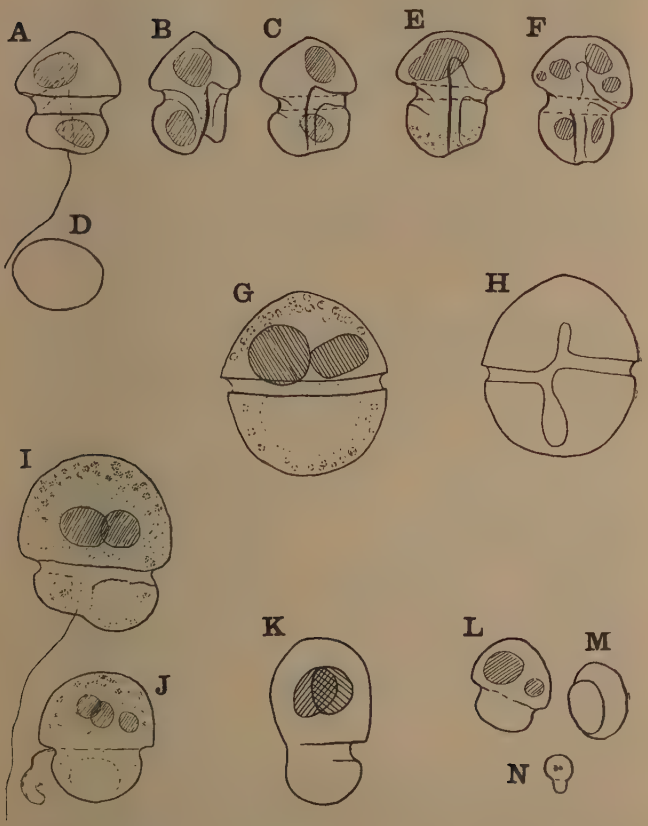


FIG. 1.—*Gymnodinium*; colourless holozoic species. All × 1600. A–F, *G. blax*: A–D, one specimen in different aspects; E, F, two other specimens. G, H, *G. colymbeticum*, a specimen in two different aspects. I–N, *G. fungiforme*: I, K, one specimen; J, another; L, M, another; N, a very minute specimen. Stippled material represents protoplasmic granules. Shading represents ingested food-particles.

hypoconus oblique truncatus. *Periplastus* rigidus in morte formam retinens. *Cingulum* profundum ab origine, sed gradatim evanescens, transversum in origine et in parte posteriori, magnopere perversum in parte anteriori. *Sulcus* profundus, conspicuus, plerumque in hypocono positus. *Chromatophora* absentia, stigmate absente. *Cytoplasma* granulare, pellucidum, algas voratas complexum et in hypocono amylum. *Flagellum* longitudinale longitudini corporis paene aequilongum. *Motus* lentus, saepe moratus. *Propagatio* in statu mobili. *Dimensiones* normales $10\mu \times 7\mu \times 6\mu$; *maxima* $11\mu$, *minima* $6\mu$ (cellula filiali non disjuncta).

The name *blax* is from βλάξ, lazy, and refers to the slow manner of swimming.

Ditch, Playhatch, 0° 55′ 33″ W., 51° 28′ 30″ N., September 1936.

2. **Gymnodinium colymbeticum,** sp. nov. (Fig. 1, G, H.) *Cellula* rotunda: epiconus hypocono aequalis vel aliquando multo major. *Cingulum* conspicuum, paulum perversum. *Sulcus* obscurus, quoad cellula contracta est, in hypocono major quam in epicono. *Periplastus* fragilis. *Protoplasma* non coloratum, algas voratas complexum, chromatophoris absentibus, stigmate absente. *Alimentum* repositum in subsidio granula non colorata. *Motus* velox. *Dimensiones* normales $16\mu \times 16\mu$.

*G. colymbeticum* was found in numbers in a tub of algae in Reading University grounds in March and April 1937. Its flagella were not observed.

This species has some resemblance to *Massartia vorticella* and to *G. fungiforme*, but from both is distinguished by its shape.

The name *colymbeticum* is from κολυμβητικός, a swift swimmer.

3. Gymnodinium fungiforme Anisimowa. (Fig. 1, I–N.) See Schiller, 1933, p. 359, for references.

The small species shown here appears to agree closely with Anisimowa's specimens. The sulcus, which is confined to the hypocone, is indistinct; chromatophores are absent, nutrition being holozoic; the food-reserve is of colourless granules, not starch; the periplast is very delicate. The organism swims rapidly with a swaying motion.

The dimensions are very varied; the largest seen was $19\mu \times 15\mu \times 10\mu$, the smallest $4\mu$ long.

Pond near Wokingham, 0° 49′ 20″ W., 51° 23′ 30″ N.

GROUP B.—*Species possessing chromatophores. Nutrition mostly holophytic, but solid food occasionally ingested.*

4. **Gymnodinium impar,** sp. nov. (Fig. 2, J–L.) *Cellula* ovalis, vix compressa: epiconus hypocono subaequalis, rotundus: hypoconus in acumina duo inaequalia divisus quorum majus in linea mediana positum minus a latere. *Cingulum* latum, profundum. *Sulcus* obscurus, omnino in hypocono. *Chromatophora* simplicia vel duplicia, margine non bene distincta, colore flava. *Amylum* defectum: alimentum repositum in subsidio granula magna et granula lucida et guttulae olei fusci. *Stigma* absens. *Cytoplasma* haud coloratum, sed vix pellucidum. *Flagellum* longitudinale breve. *Periplastus* rigidus, formam in morte retinens. *Propagatio* in statu mobili. *Motus* lentus, saepe circumagens et cursum flectens. *Dimensiones* normales $12\mu \times 11\mu$, minimae $10\mu \times 8\mu$.

This species is common in winter and spring in peaty lakes, pools, and ditches: it was noticed in water from similar pools in the Lake District. So far as is known, it never ingests solid food.

The name *impar* refers to the unequal divisions of the hypocone.

5. **Gymnodinium cnecoides,** sp. nov. (Fig. 2, A–D.) *Cellula* rotunda, dorsiventraliter paulum compressa: epiconus hypocono subaequalis: ambo rotundati. *Cingulum* latum, aecurate transversum. *Sulcus* omnino in hypocono, conspicuus. *Periplastus* fragilis, corporis in morte fere liquefactus. *Chromatophora* simplicia vel duplicia, colore pallide flava, in massulas incompositas in utraque parte corporis aggregata. *Protoplasma* algas voratas complexum: amylum defectum: alimentum repositum in subsidio granula lucida praebens. *Stigma* absens. *Vacuolum* magnum in hypocono positum. *Flagellum* longitudinale breve; flagellum transversum in cingulo positum. *Motus* haud celer, sed nutans et interdum cursum flectens. *Propagatio* in statu mobili. *Dimensiones* normales $9\mu \times 8\mu$, maximae $14\mu \times 11\mu$.

Pond near Penge Wood, containing many other flagellates and higher plants, 1° 0′ 40″ W., 51° 24′ 26″ N., May 1936.

The name refers to its exceedingly pale plastid.

6. **Gymnodinium discoidale,** sp. nov. (Fig. 2, G–I.) *Cellula* ovalis, magnopere dorsiventraliter compressa: epiconus paulum apiculatus. *Cingulum* transversum. *Sulcus* non profundus, in longitudine positus, pro parte majori in hypocono. *Chromatophora* ut probabile est geminata, unum in epicono, alterum in hypocono, colore pallide flava. *Protoplasma*

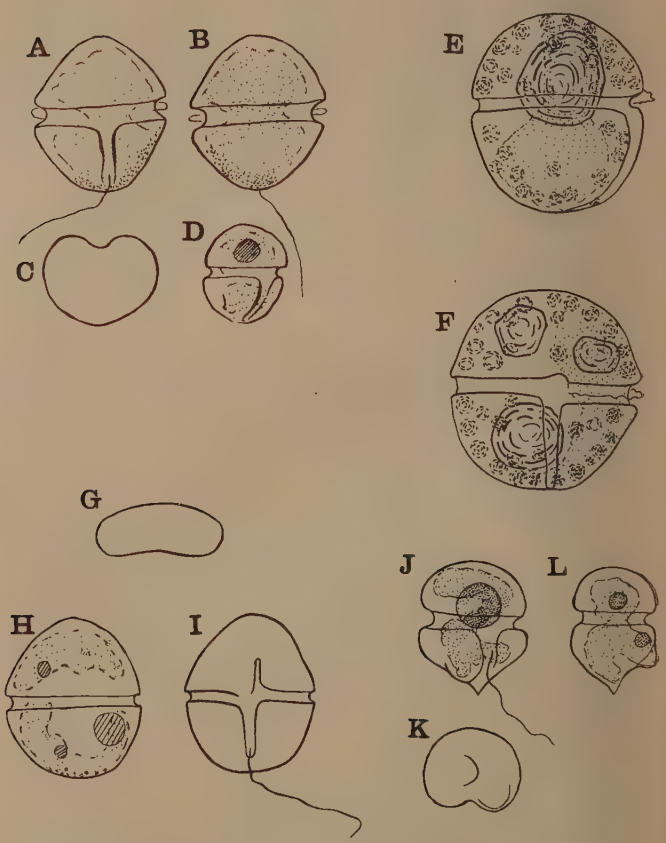


Fig. 2.—*Gymnodinium*; small forms with plastids. All × 1600. A–D, *G. cnecoides*: A, B, C, one specimen from different aspects; D, another. E, F, *G. saginatum*: two specimens; in E, the cell is so placed that the sulcus is to the right. G–I, *G. discoidale*: one specimen from three aspects. J–L, *G. impar*: J, K, one specimen from two aspects; L, another specimen. In these figures the large stippled body is the plastid, ingested food is cross-shaded; other protoplasmic granules and food-reserve are shown by stippling or broken lines.

aliquantum granulosum, algas parvas voratas complexum. *Alimentum* repositum in subsidio granula lucida praeter granula parvula amyli in parte posteriori. *Stigma* absens. *Flagellum* longitudinale longitudini corporis fere aequale. *Periplastus* praeter modum rigidus, in morte formam retinens. *Motus* mediocriter celer, circumagens sed cursum plerumque retensus. *Dimensiones* maximae $16\mu \times 14\mu \times 7\mu$, minimae $12\mu \times 10\mu \times 5\mu$.

Shallow roadside ditch, Buckleberry Common, 1° 12′ 0″ W., 51° 25′ 0″ N., January 1939.

This species is like certain flat species of *Glenodinium*, but no wall could be separated from the protoplasm by plasmolysis. Reproduction was not observed.

7. **Gymnodinium saginatum,** sp. nov. (Fig. 2, E, F.) *Cellula* ovalis vel fere globosa, vix compressa: epiconus hypocono aequalis. *Cingulum* mediocriter profundum, transversum. *Sulcus* intra fines hypoconi terminatus sed ad fines extendens. *Periplastus* mediocriter rigidus, chromatophoro unico colore pallide flavo, stigmate absente. *Cytoplasma* non coloratum, superficie granula pellucida multa ostendens, parte interiori guttulas olei colore castaneas complexum, amylo deficiente. *Flagellum* transversum manifestum et impigrum; flagellum longitudinale raro manifestum, plus minusve dimidio longitudini corporis longius. *Motus* tardissimus et interdum cursum flectens. *Dimensiones* maximae $23\mu \times 20\mu$, minimae $18\mu \times 18\mu$.

In an acid oligotrophic pool near Wokingham, 0° 50′ 0″ W., 51° 22′ 5″ N., February 1939. Also in other peaty pools in autumn and winter.

The name refers to its plump form.

This species, which was represented by many specimens, is conspicuous by reason of its globular form, granular cytoplasm, and remarkably weak swimming, which is due entirely to the transverse flagellum. In most individuals no longitudinal flagellum appears to be present at all. A small individual in which the epicone was smaller and flatter than the hypocone was noted: it was probably a young one.

It is not known to ingest solid food. The periplast, although rather firm, dissolves in alkali at once.

*G. saginatum* is near the rather indefinite species *G. albulum* Lindemann, but is distinguished by its narrower girdle.

8. Gymnodinium aeruginosum Stein. (Fig. 3, A, B.) See Schiller, 1933, p. 327, for references.

This beautiful organism has been found as occasional individuals in a number of ponds at all times of the year. Two individuals are shown in a slightly shrunk state in glycerine;

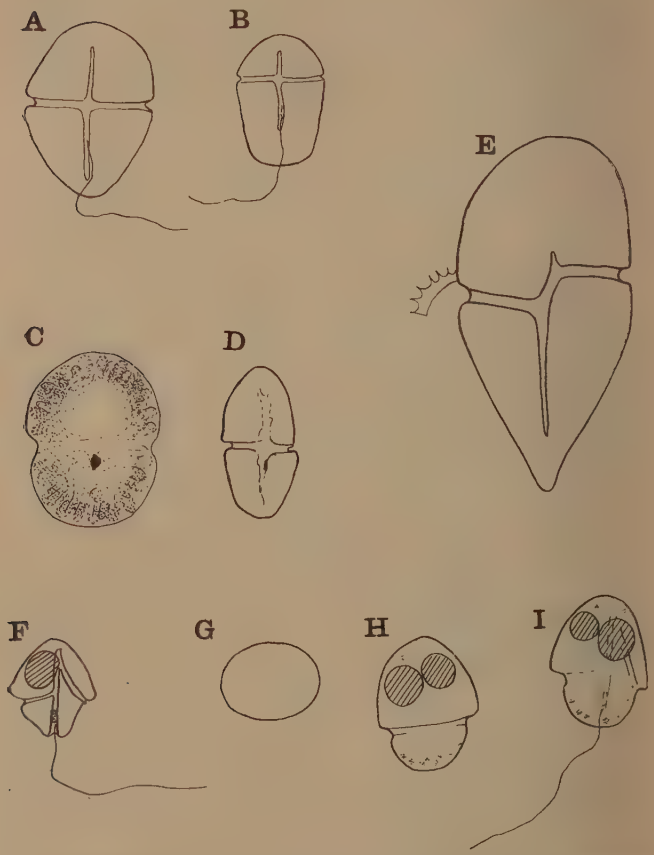


FIG. 3.—*Gymnodinium*, large forms with plastids, and *Massartia*. A, B, *G. aeruginosum* : outlines of small and large specimens both slightly shrunk to show the furrows, ×800. C, D, *G.* cf. *paradoxum* : C, normal specimen showing plastid and stigma ; D, the same strongly shrunk in glycerine, ×800. E, *G. fuscum* : outline drawing of specimen in weak sugar solution showing a portion of the transverse flagellum which has come out of its groove, ×800. F–I, *Massartia ptyrtica* : F, specimen shrunk in sugar ; G, H, I, another specimen, ×1600.

the left is typical, the right is unusually small and with an unusually high girdle. It has been found in other parts of Britain.

No specimens were observed to contain ingested food.

9. Gymnodinium sp., cf. *G. paradoxum* Schilling. (Fig. 3, C, D.) Body oval, somewhat dorsiventrally flattened; epicone very slightly larger than hypocone, both ends rounded, girdle very ill-marked, sulcus scarcely recognizable, but appearing to extend into both epicone and hypocone when caused to shrink. Periplast very firm with an exceedingly thin test or wall in some specimens. Plastids numerous, brown, radiating; starch scanty or absent. Stigma round, dark red. Nutrition holophytic.

Dimensions 29 $\mu$ long $\times$ 24 $\mu$ broad.

Pond, Reading, University grounds, 1 April 1936.

This *Gymnodinium* resembles *G. paradoxum* Schilling in most of its characters (see Schiller, 1933, p. 397), but differs in being considerably smaller, 29 $\mu$ long against 39 $\mu$ long, in having a round instead of elongated stigma and possibly in its radiating plastids. These differences are not, however, enough to make it worth distinguishing under a name. It is very close also to some species of *Glenodinium*.

10. Gymnodinium fuscum (Ehrenb.) Stein. (Fig. 3, E.) See Schiller, 1933, p. 359, for references.

This fine species was found once only in this district; in a pool of acid peaty water near Wokingham, together with other species characteristic of this type of habitat. It was, however, noted in similar water near Wray Castle, Westmorland, where it appears to be common. February 1939.

## The Genus Massartia Conrad.

Group A.—*Species without chromatophores; nutrition holozoic.*

1. **Massartia campylops,** sp. nov. (Fig. 4, A–D.) *Cellula* late ovalis, dorsiventraliter compressa: epiconus ter longior quam hypoconus, extremis ambobus rotundis. *Cingulum* profundum. *Chromatophora* absentia: protoplasma pellucidum, saepe algas ingestas complexum; alimentum repositum in subsidio in epicono granula non colorata, amylo deficiente. *Stigma* praeclarum, rubrum, forma simile soleae ferreae equi, in sulco *Flagellum* longitudinale longius quam corpus: flagellum transversale in cingulo retentum. *Periplasti* fragiles: corpus in morte liquefactum. *Motus* celer, nonnihil quassans. *Dimensiones* normales 15 $\mu \times 12\,\mu \times 7\,\mu$, maximae 16 $\mu \times 13\,\mu$ minimae 12 $\mu \times 10\,\mu$.

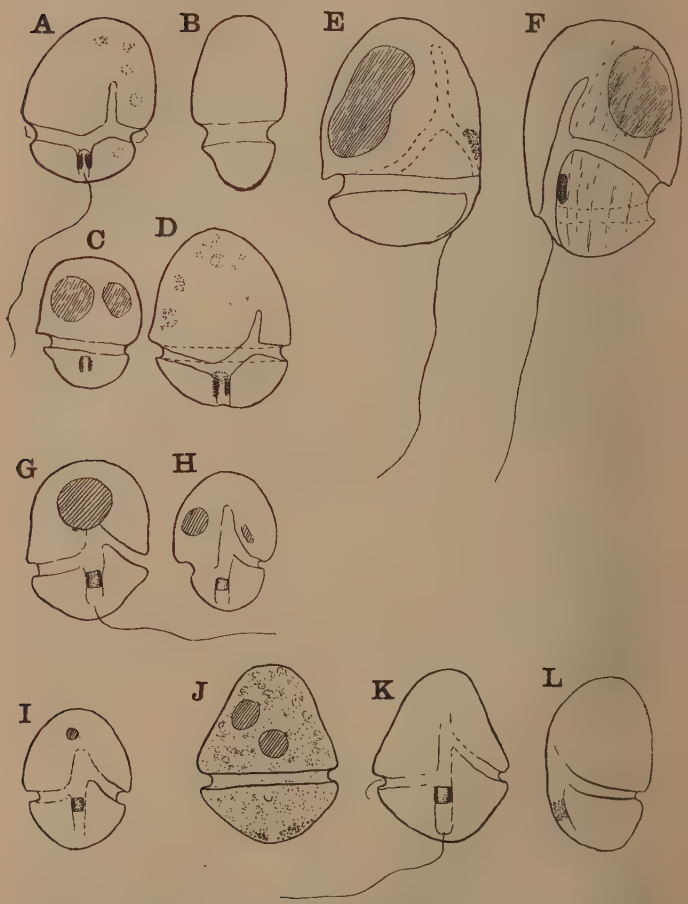


Fig. 4.—*Massartia*; colourless holozoic species. All × 1600. A–D, *M. campylops*: A, B, one specimen; C, D, others in different aspects. E, F, *M. molopica*: two individuals, both slightly shrunk with glycerine; F, shows the striations. G–L, *M. tetragonops*: G, H, I, different specimens; J, K, L, one specimen from different aspects. Light stippling represents protoplasmic or food-reserve granules; the eyespot is darkly stippled. Ingested food is shown by cross-shading.

Reproduction was not observed in this species.

Eutrophic pond, Penge Wood, 1° 0′ 40″ W., 51° 24′ 26″ N., May 1936.

2. **Massartia tetragonops,** sp. nov. (Fig. 4, G–L.) *Cellula* vel ovalis vel rotunda, minima, dorsiventraliter compressa: epiconus plerumque multo major quam hypoconus, terminis ambobus rotundis (quoad cytoplasma contracta sit apiculatis). *Periplastus* fragilis; in morte corpus liquifactum. *Cingulum* profundum in dorso, sed tenuissimum et obscurum in ventre (nisi corpus contractum), nonnihil perversum. *Sulcus* obscurus (nisi corpus contractum), dimidio brevior quam corpus. *Chromatophora* defecta. *Protoplasma* non coloratum, granulare, algas ingestas complexum et in antapice vestigia amyli. *Flagellum* longitudinale fere corporis longitudinem aequans: flagellum transversum in cingulo retentum. *Stigma* in sulco, colore pallide badium, marginibus fuscius (?complectum), forma tetragonum. *Propagatio* motilis. *Motus* vel celer vel tardior, saepe circumagens. *Dimensiones* normales $16\mu \times 13\mu \times 11\mu$, maximae (ante divisionem) $16{\cdot}5\mu \times 16\mu$, minimae (cellula filia non disjuncta) $12{\cdot}5\mu \times 12\mu$.

This species is the commonest of the holozoic Gymnodiniaceae. It was found at all times of year in many eutrophic ponds and tanks.

The different collections show some variation; occasionally the two halves of the cell are almost equal (when the species would be placed in *Gymnodinium*); and one collection showed a round instead of a square eye-spot.

*M. tetragonops* is rather like *Massartia stigmaticum* (see Schiller, 1933, p. 441), but differs in the shape of the stigma and probably also in the course of the girdle.

3. **Massartia molopica,** sp. nov. (Fig. 4, E, F.) *Cellula* ovalis, non dorsiventraliter compressa: epiconus ter major quam hypoconus, ambobus extremis rotundis. *Periplastus* fragilis, striis longitudinalibus exilibus notatus. *Cingulum* profundum, spirale, ex medio corporis fere ad antapicem extensum. *Sulcus* profundus, obliquus, fere ex apice fere ad antapicem extensus. *Cytoplasma* lucidum, non coloratum, algas voratas complexum: chromatophora non visa, amylo deficiente. *Stigma* rubidum, elongatum. *Flagellum* longitudinale corpori aequilongum vel bis longius. *Motus* celer. *Dimensiones* constantes $21\mu \times 15\mu$.

Shallow eutrophic pond with many flagellates. Shinfield, 0° 56′ 30″ W., 51° 23′ 52″ N., May 1936.

The name *molopica* is from μωλωπικός, covered with scars, and refers to the striated periplast.

This species, *M. hyperxanthus* and *M. hyperxanthoides* could almost equally well be placed in *Gyrodinium*.

4. **Massartia ptyrtica,** sp. nov. (Fig. 3, F–I.) *Cellula* ovalis, paulum dorsiventraliter compressa : epiconus multo major et latior quam hypoconus, apice paulum acutior, antapice paulum planior. *Cingulum* obliquum, fere ex antapice ad medium corporis extensum. *Sulcus* longus, obscurus quoad cellula contracta est, in longitudine positus. *Periplastus* rigidus. *Flagellum* longitudinale longius quam corpus. *Stigma* subrubicundum, longum. *Protoplasma* non coloratum, clarum, chromatophoris absentibus, algas voratas complexum : alimentum repositum in subsidio granula minuta, amylo deficiente. *Motus* singularis ; cellula immota diu manet, quoad trepidata, tunc porro celerrime se conjicit. *Dimensiones* normales $12\mu \times 9\mu \times 7\mu$, minima $8\mu$ longitudine.

This small species is common in eutrophic roadside ditches and small ponds in early spring. The figured specimens were from Earley, 0° 56′ 30″ W., 51° 25′ 40″ N., March 1939.

Reproduction was not observed. This species, while sufficiently distinguished by its shape, is most remarkable for its swimming. It remains still and apparently attached to a solid indefinitely, but when startled darts off a short distance and then stops again. Owing to the spiral course of the girdle, it could be placed almost as well in *Gyrodinium*, but it differs so much from the marine species of that genus that it seems best included here.

The name is from πτυρτικός, apt to shy.

GROUP B.—*Species with chromatophores (but nutrition partly holozoic).*

5. **Massartia hyperxantha,** sp. nov. (Fig. 5, A–F.) *Cellula* ovalis, aliquantum dorsiventraliter compressa : epiconus longior et latior quam hypoconus, terminis ambobus rotundis. *Cingulum* spirale, conspicuum, sed in ventre tenue. *Sulcus* obscurus, subobliquus, per majorem partem cellulae extensus. *Periplastus* fragilis ; corpus in morte liquefactum. *Stigma* parvum, rubidum, sub sulco profunde positum. *Chromatophorum* simplex vel duplex, margine lobatum et obscurum, colore pallide flavum. *Amylum* deficiens ; protoplasma algas ingestas complexum. *Flagellum* longitudinale aliquantum longius quam corpus : flagellum transversale in cingulo inclusum. *Motus* rotans et nutans sed non sine progressione. *Dimensiones* typicae $12\mu \times 10\mu \times 7\mu$, maxima $14\mu$ longitudine.

Eutrophic, in a cow-trough, Earley, 0° 56′ 20″ W., 51° 25′ 40″ N., July 1935.

The name *hyperxantha* refers to the colour of the plastid.

6. **Massartia hyperxanthoides,** sp. nov. (Fig. 5, G–I.) *Cellula* ovalis, aliquantum dorsiventraliter compressa : epiconus magnopere longior et latior quam hypoconus. *Cingulum*

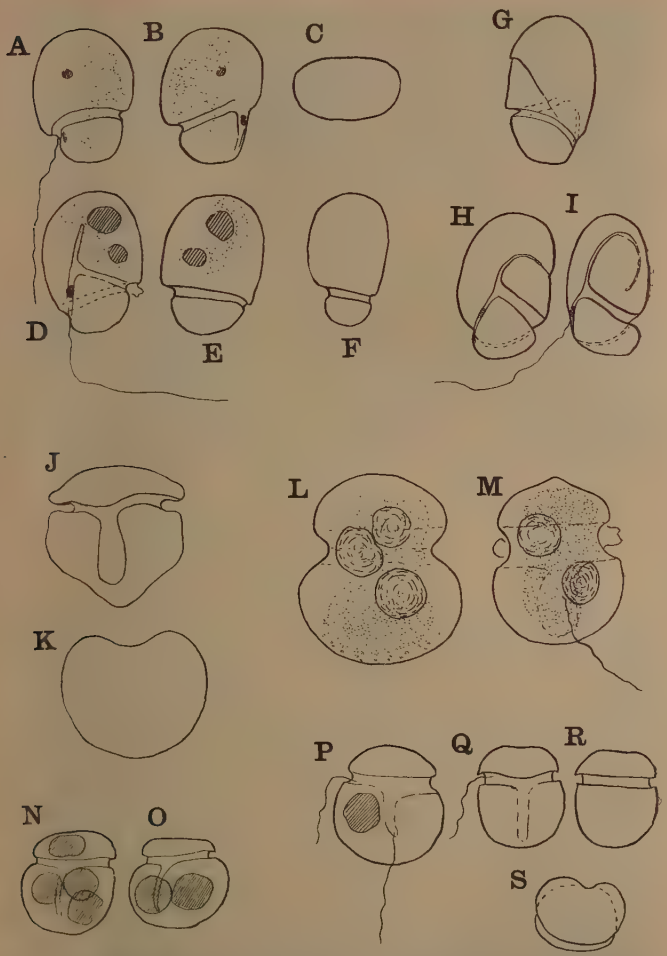


FIG. 5.—*Amphidinium* and *Massartia*. All ×1600. A–F, *M. hyperxantha*: A, B, C, one specimen; D, E, F, another specimen. G–I, *M. hyperxanthoides*: outline drawings of a specimen from three aspects. J–M, *A. tenagodes*: J, individual strongly shrunk in glycerine; K, hypocone; L, M, two normal individuals. The large bodies are most probably food-reserve. N–S, *A. gyrinum*: N, O, P, different specimens; Q, R, S, views of the same specimen. Ingested food is indicated by cross shading; the lightly stippled masses are the plastids; eye-spot more darkly stippled.

spirale, conspicuum, fere e medio corporis fere ad antapicem extensum. *Sulcus* obliquus, magnopere curvatus, e cingulo fere ad apicem et protinus ad antapicem extensus. *Periplastus* rigidus, in morte in magna parte formam retinens. *Chromatophora* duo, pallidissime flava. *Amylum* deficiens. *Stigma* subrubicundum, parvum. *Protoplasma* algas ingestas saepe complexum. *Flagellum* longitudinale corpori aequilongum. *Motus* rotans. *Dimensio* normalis 15 $\mu$ longitudine sed saepe minor.

Eutrophic trough, Earley, 0° 55′ 50″ W., 51° 25′ 30″ N., August 1936.

The name refers to its resemblance to *M. hyperxantha*.

*M. hyperxanthoides* is very like *M. hyperxantha*, but differs in its firmer periplast, its sulcus, and its stigma, and thus appears worthy of specific rather than varietal rank.

An organism of very similar form, but apparently without any plastid was noticed in a pond at Wray Castle, Ambleside, Westmorland, in April 1938. It may be noted that small individuals of *M. hyperxanthoides* appear nearly colourless.

## The genus Amphidinium Claparède & Lachman.

### Group A.—*Species lacking chromatophores, nutrition holozoic.*

1. **Amphidinium aeschrum,** sp. nov. (Fig. 6.) *Cellula* ovalis, dorsiventraliter compressa : epiconus plerumque multo minor quam hypoconus. *Cingulum* perobliquum, conspicuum, integrum, aliquantulum perversum. *Sulcus* obscurus, per longitudinem cellulae extensus. *Periplastus* fragilis, in morte liquefactus. *Stigma* rubidum, elongatum. *Vacuolus* parvus, prope antapicem positus. *Chromatophora* absentia ; protoplasma non-coloratum, sed granula et algas ingestas complexum, atque vestigia amyli in hypocono. *Flagellum* longitudinale bis longius quam corpus, flagellum transversale in cingulo inclusum. *Motus* celer, nutans et aliquanto rotans. *Dimensiones* typicae 20 $\mu \times 13\,\mu \times 18\,\mu$.

Among filamentous algae in a Thames lock (eutrophic) at Mapledurham, 1° 2′ 12″ W., 51° 29′ 3″ N., June 1936.

The name refers to its inelegant shape.

2. **Amphidinium gyrinum,** sp. nov. (Fig. 5, N–S.) *Cellula* rotunda, parum dorsiventraliter compressa : epiconus tertiam partem hypoconi aequans, planus. *Periplastus* fragilis, in morte liquefactus. *Cingulum* profundum, conspicuum, accurate transversum. *Sulcus* omnino in hypocono positus, in origine profundus, sed prope antapicem minus profundus. *Chromatophora* absentia ; protoplasma non coloratum, algas

ingestas saepe complexum. *Stigma* absens : amylum deficiens. *Flagellum* longitudinale fere longitudini corporis aequilongum : flagellum transversum saepe ex cingulo extensum. *Motus* tardus, sed in cursu celeriter rotans. *Dimensiones* typicae $9\mu \times 8\mu \times 6$–$7\mu$, maxima $11\mu$ longitudine.

Experimental tubs at the University Botanic Garden, Reading (eutrophic), with abundant Volvocales ; found at all seasons.

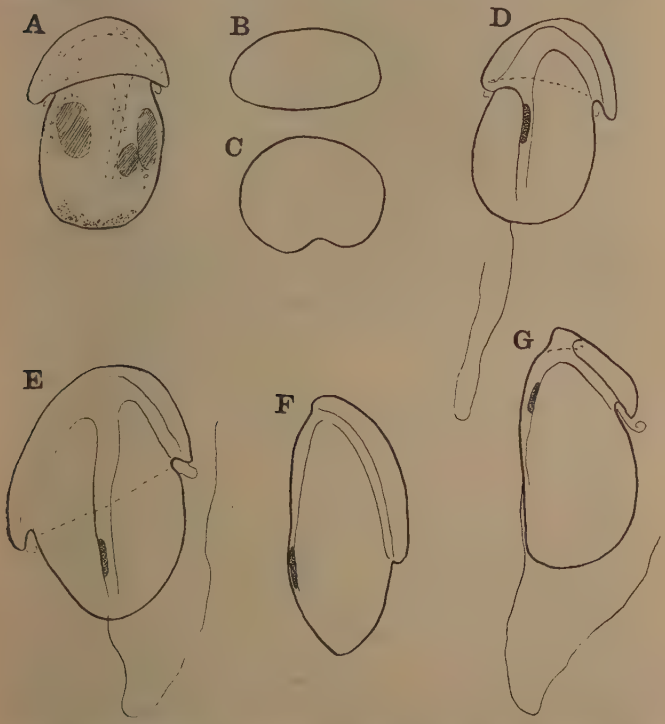


Fig. 6.—*Amphidinium aeschrum*. ×1600. A–D, one specimen in different aspects : B is the epicone and C the hypocone in end view ; E, F, large specimen with epicone of unusual extent ; G, side view of another specimen. Small granules represent food-material ; the stigma is darkly stippled ; ingested food is represented by cross-shading.

The name refers to the spinning motion.

*A. gyrinum* is closely similar to *A. Elenkinii* (see Schiller, 1933, p. 288), but differs in constantly lacking chromatophores and in its shorter flagellum. Its reproduction was not observed.

GROUP B.—*Species with chromatophores, nutrition holophytic.*

3. **Amphidinium tenagodes,** sp. nov. (Fig. 5, J–M.) *Cellula* ovalis, parum dorsiventraliter compressa : epiconus plerumque tertiae parti cellulae aequalis, nonnunquam fere dimidio, rotundus vel planus : hypoconus rotundus. *Cingulum* latum, profundum, sed margine obscurum, fere accurate transversum. *Sulcus* latus, solum in hypocono, obscurus quoad cellula contracta est. *Chromatophora* verisimiliter duo, magna, palidissime flava. *Stigma* absens. *Flagellum* longitudinale minus quam longitudo corporis. *Periplastus* fragilis, in morte liquefactus. *Alimentum* repositum in subsidio granula magna lucida, atque vestigia amyli in hypocono. *Motus* tardissimus, saepe rotans. *Dimensiones* normales $17\mu \times 15\mu \times 12\mu$.

*A. tenagodes* was found in water with many dead leaves in March in the University grounds, Reading, in fairly large numbers. Though it swims feebly it keeps to the surface-layers of water in the daytime. The large granules of metabolite look rather like ingested cells, but are probably not of this nature as they never show structure and dissolve when the cell dies. No specimen showed definite ingested organisms.

*A. tenagodes* resembles *A. Elenkinii* (see Schiller, 1933, p. 288), but is distinguished by its shorter flagellum and shallower sulcus. It might almost equally well be placed in *Gymnodinium*, as the girdle is sometimes in the middle.

The name refers to the shallow sulcus.

## GLENODINIACEAE.

This group, which is for the most part distinguished by the very thin wall or test, is discussed below.

*Glenodinium* (*sensu lato*) : girdle going right round cell.

*Hemidinium* : girdle going half round cell.

*Discussion.*—Of recent authors Lebour (1925) conformed with the older view on these forms by classifying them chiefly on the shape of the cell, while Schiller (1937), following Woloszynska, drastically alters it by basing classification on plating structure, and on this basis divides *Glenodinium* (sensu lato) into two families with numerous genera.

Although it seems that the classification on plating structure is fundamental, I have not adopted it, because of my inability to make satisfactory use of it. I succeeded in demonstrating the existence of plates in specimens of cleared tests stained in Trypan blue, but could not do this completely and with the certainty needed for description. To make out the plating fully, numerous well-developed specimens of a single species

seem needed, and with occasional specimens in a mixed sample it must be very difficult.

I would, therefore, plead that those who describe the plating structure should also describe with equal care such features as the external shape, plastids, eye-spot, metabolites, and methods of swimming which can be readily observed in living specimens, and which may often help to characterize a species. Meanwhile, I have for the present omitted any description of the small brown species which other authors seem to have referred to *oculatum*, *paradoxum*, *palustre*; though these occur in nearly every pond. I am convinced that my specimens belong to many more species than these three. I have, however, described in detail those which are of more unusual appearance.

The criteria on which a 'distinct' test is distinguished from a mere firm periplast (of some Gymnodiniaceae) are given on p. 6.

## The genus Glenodinium Stein. (See p. 20.)

The species described here are grouped as follows:—(*a*) Colourless holozoic species. (*b*) Forms with chromatophores, cell rounded. (*c*) Forms with chromatophores, cell dorsiventrally flattened.

### Group A.—*Colourless holozoic species.*

1. **Glenodinium punctulatum,** sp. nov. (Fig. 7, E, F.) *Cellula* ovalis, vix dorsiventraliter compressa: epiconus hypocono aequalis. *Theca* tenuissima sed firma, foveis parvis elongatis ornata. *Cingulum* latissimum, non profundum, marginibus projicientibus tenuibus. *Sulcus* latus, obscurus. *Protoplasma* non coloratum, sed granula amyli et algas ingestas complexum. *Chromatophora* absentia: stigma absens. *Motus* celer. *Dimensiones* maximae $24\mu \times 18\mu \times 19{\cdot}5\mu$, minimae $15\mu \times 12\mu$.

Large eutrophic pond, Penge Wood, 1° 0′ 3″ W., 51° 25′ 0″ N., February 1938.

*G. punctulatum* is distinguished from the other holozoic *Glenodinium* species by its oval shape, scarcely sunken transverse groove, and its very thin, finely pitted wall. Its flagella and its reproduction were not observed.

2. **Glenodinium leptodermum,** sp. nov. (Fig. 7, A, B.) *Cellula* ovalis, aliquantulum dorsiventraliter compressa: epiconus fere hypocono aequalis. *Theca* tenuissima, in cellulis parvis absens. *Cingulum* aliquantulum profundum, paululum perversum. *Sulcus* obscurus quoad cellula contracta est, fere per majorem partem cellulae extensus. *Stigma* parvum,

rubidum. *Chromatophora* absentia : protoplasma non coloratum, granula lucida et algas voratas complexum. *Amylum* deficiens. *Flagellum* longitudinale longius quam corpus. *Motus* aliquantulum celer, interdum nutans et rotans. *Dimensiones* maximae $24\mu \times 16\mu \times 12\mu$, mimina $14\mu$ longitudine.

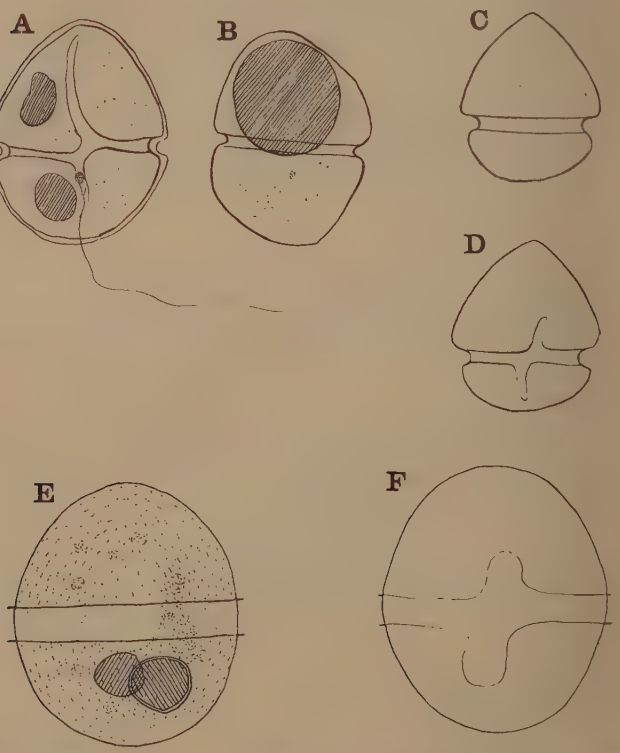


Fig. 7.—*Glenodinium* : colourless holozoic species. All × 1600. A, B, *G. leptodermum* : A is slightly plasmolyzed ; B, another specimen in normal state. (Eye-spot shown darkly stippled.) C, D, *G.* cf. *edax* : outline drawings of one specimen. E, F, *G. punctulatum* : two views of one specimen. The dots in orientated groups are faint striations on the shell. In A, B, E ingested food is cross-shaded ; protoplasmic granules and food-reserve lightly stippled.

This species occurred in large numbers in eutrophic water in a water-butt in the University Horticultural ground, Reading, in July 1936.

3. GLENODINIUM sp., cf. *edax* Schilling. (Fig. 7, C, D.) See Schiller, 1937, p. 100.

The specimen figured agrees with *G. edax* in being colourless and in its form, but differs in being $16\mu \times 16\mu \times 10\mu$, which is about half the normal size. No stigma is present.

Only one specimen was seen.

Mortimer Cross pond, 1° 3′ 30″ W., 51° 22′ 35″ N., October 1936.

GROUP B.—*Species with plastids, not strongly flattened; solid food rarely ingested.*

4. **Glenodinium helicozoster,** sp. nov. (Fig. 8, D–H.) *Cellula* ovalis: epiconus amplitudine similis hypocono sed plerumque latior: epiconus obtusus: hypoconus planus: epiconus paulum, hypoconus forte dorsiventraliter compressus. *Theca* tenuissima, in cellulis maximis solum praesens, sed periplasto semper rigido. *Cingulum* conspicuum, multo perversum. *Sulcus* obscurus, praecipue in hypocono obvius. *Chromatophora* multa et fulva et discoidalia. *Stigma* absens: vacuolus aliquantum magnus: amylum in hypocono abundans. *Flagellum* longitudinale longius quam corpus aliquantulum quietum, flagellum transversale saepe ex cingulo extendens, tum impigrius. *Motus* tardus, cursum saepe flectens et subito regrediens. *Propagatio* in statu mobile. *Dimensiones* maximae $24\mu \times 22\mu \times 19\mu$, normalis $20\mu$ longitudine sed saepe minor.

In water with rotting leaves, October to May; University grounds, Reading, and various ditches and ponds.

This species seems intermediate between *Glenodinium* and *Gymnodinium*. Although the periplast in all specimens is rigid enough to preserve the shape of the cell, it is often quite impossible to separate the protoplasm from it by plasmolysis.

It was, moreover, impossible to demonstrate plates in the test even of the best-developed specimens. The substance of the test is rather quickly swollen and dissolved by sodium hypochlorite, while potash alone does not sufficiently remove the protoplasm.

This species changes slightly as the season progresses; in the autumn the cells are rather small and very pale, being often nearly colourless, but by mid-winter they are mostly larger and browner and by spring the small form is relatively rare. This was noticed in four different years. It seems very probable that the pale form is almost entirely saprophytic in its nutrition, since it is to be found in water very rich in brown substances derived from rotting leaves.

The name refers to the spiral course of the girdle.

5. **Glenodinium eurystomum,** sp. nov. (Fig. 9, K–M.) *Cellula* ovalis, aliquantulum dorsiventraliter compressa : epiconus plerumque major quam hypoconus : theca tenuis,

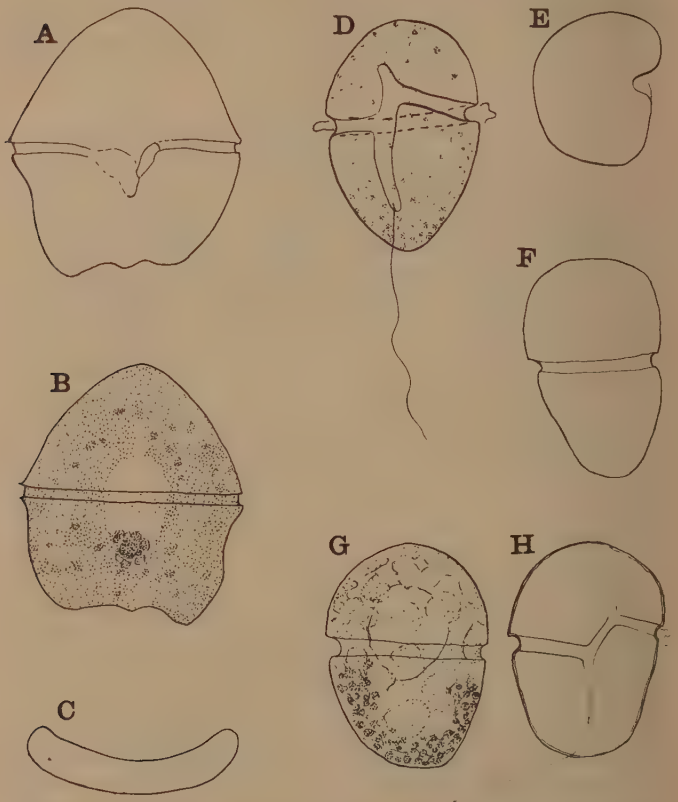


Fig. 8.—*Glenodinium* ; coloured species. All × 800. A–C, three views of *G. limpos.* Most of the cytoplasm appears evenly brown, but there are some darker granules. D–H, *G. helicozoster* : D, E, F, a specimen of the form predominating in autumn ; the plastid is very pale and indefinite. G, H, a specimen of the form predominating in spring ; the plastid is more conspicuous. Stippled granules are starch-grains.

sed etiam in cellulis minimis praesens. *Cingulum* profundum et manifestum in dorso, obscurum et obliquum in ventre. *Sulcus* obscurus et aliquantulum angustus in hypocono.

latissimus sed obscurus in epicono. *Stigma* absens. *Chromatophora* duo, unum in hypocono, alterum in epicono, plerumque pallide flava sed aliquando fusca. *Protoplasma* saepe algas ingestas complexum, et granula parva amyli in hypocono et in epicono insita. *Motus* aliquantum celer, plerumque prorsus, id est non nutando, sed aliquanto rotando. *Dimensiones* maximae $17\mu \times 14\mu \times 8$–$10\mu$, longitudine minima $10\mu$.

Small oligotrophic pools in peaty bog ; Silchester Common, 1° 6′ 25″ W., 51° 21′ 12″ N., July 1936.

The name refers to the wide mouth-like sulcus.

GROUP C.—*Species with plastids ; cell strongly flattened dorsiventrally.*

6. **Glenodinium limos,** sp. nov. (Fig. 8, A–C.) *Cellula* magnopere dorsiventraliter compressa : epiconus fere hypocono aequalis : hypoconus bullis obtusis tribus ornatus. *Cingulum* aliquantum manifestum in dorso, obscurum in ventre : sulcus brevissimus et obscurus. *Periplastus* rigidus, sed theca non manifesta. *Chromatophora* obscura, corpore toto fusco. *Cytoplasma* granula obscura includens in apice, media regione clarum, vestigia amyli in antapice exhibens. *Stigma* absens. *Motus* tardus, rotans, minime progrediens. *Dimensiones* $46\mu \times 40\mu$ (specimen unicum).

Large eutrophic pond, Penge Wood, 1° 0′ 3″ W., 51° 25′ 0″ N., February 1938.

The name refers to the hollow ventral surface.

This species is near *G. foliaceum* (see Schiller, 1935, p. 120), but is well distinguished by lacking a stigma. Although it was impossible to separate the protoplasm from the wall by plasmolysis, its close resemblance to *G. foliaceum* in form and its rigidity suggest that it may be correctly placed here rather than in *Gymnodinium*.

The genus HEMIDINIUM Stein.

1. HEMIDINIUM NASUTUM Stein. See Schiller, 1937, p. 89, for references.

This species is by no means common in this district, but has been found occasionally in a number of ponds at different times of year. It has been found by other authors in other parts of Britain.

A certain number of specimens apparently belonging to this species were unusual in being very small (less than $15\mu$ long), of pale colour, and having no wall from which the protoplasm could be separated by plasmolysis.

The genus TETRADINIUM Klebs.

1. **Tetradinium chiastosporum,** sp. nov. (Fig. 9, A–J.) *Cellula* dum mobilis late ovalis et dorsiventraliter compressa :

epiconus paulo minor quam hypoconus. *Cingulum* profundum, transversum vel paulo perversum; sulcus obscurus, solum in hypocono. *Periplastus* subrigidus. *Chromatophora* in

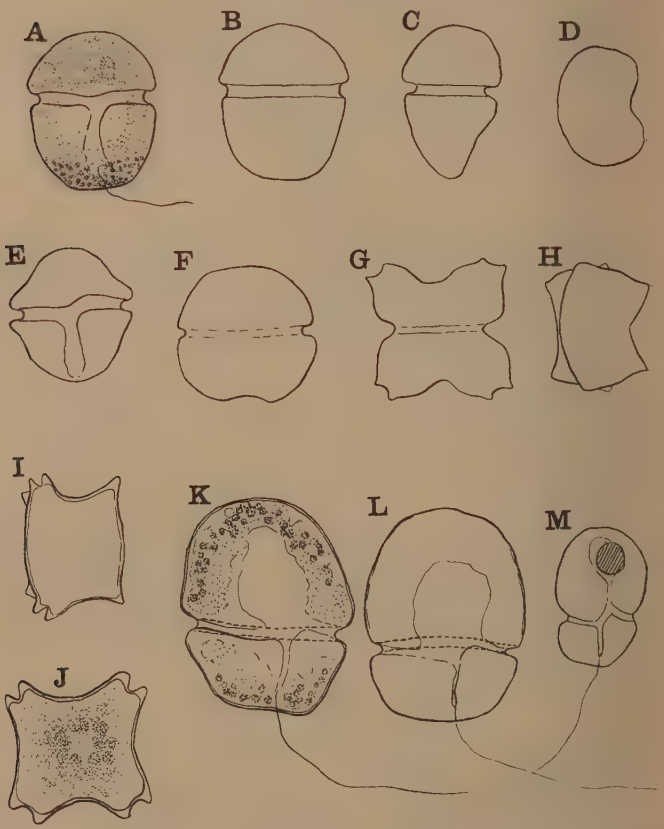


FIG. 9.—*Tetradinium*; *Glenodinium*. All × 1600. A–J, *T. chiastosporum*: A–D, four views of a specimen; E, another shrunk in glycerine; F, early stage in spore-formation; G, H, later stage (still motile); I, J, mature thick-walled spore (non-motile). K, L, M, *Glenodinium eurystomum*: different individuals. The small individual in M has ingested a food-particle. Stippled body represents a plastid; stippled granules starch food-reserve.

forma circulorum fulvorum: amylum in hypocono abundans. *Flagellum* longitudinale brevius quam corporis longitudo. *Propagatio* in statu mobile. *Motus* tardus et claudicans.

*Dimensiones* normales 14 $\mu \times 12\,\mu$, minima 12 $\mu$ longitudine. *Spora* perfecta per transformationem gradatim ex cellula mobile, quae in statu mobile manet, quoad parietes sporae crassi sint : spora nullo modo affixa, angulis quattuor bicuspidis. *Dimensiones* 13 $\mu \times 13\,\mu \times 7$–8 $\mu$.

Found in a tub full of *Lemna* in the University grounds, Reading, in March and April 1936, when it appeared and has not been found again.

This species differs from the other species of *Tetradinium* in the form of the spore, but more especially in this spore being unattached. The germination of the spore was not observed.

## PERIDINIACEAE.

### The genus Peridinium Ehrenb.

The freshwater species have been rather closely investigated by other authors and the arrangement of their principal plates is well known. I have followed Schiller (1937) in his treatment of the very numerous described species.

#### Group A.—*Species with three accessory apical plates.*

1. Peridinium cinctum Ehrenb. (Fig. 10, G–L.) See Schiller, 1937, p. 152.

This species was found in a great many ponds in winter and spring.

The commonest form (which is figured) has a flattened body and the right accessory plates are much larger than the left (*forma irregulatum*), but one pond provided specimens with an almost spherical body and equal accessory plates (*forma regulatum*). Again, most specimens have coarsely pitted plates, but from one pond they were so finely marked as to be almost smooth. In all specimens examined in detail the ant-apical plates were unequal.

This species is common in other parts of Britain.

2. Peridinium Willei Huitfeld-Kaas. (Fig. 10, A–F.) See Schiller, 1937, p. 146.

*P. Willei* is common in small ponds. It has been found at all seasons, but in at least one pond (University ' Staff pond ', Reading) it is considerably commoner in summer than at other times. The specimens figured agree with the form *stagnale* in being dorsiventrally flattened. The one shown in F has fairly broad striated bands.

This species is common in other parts of Britain.

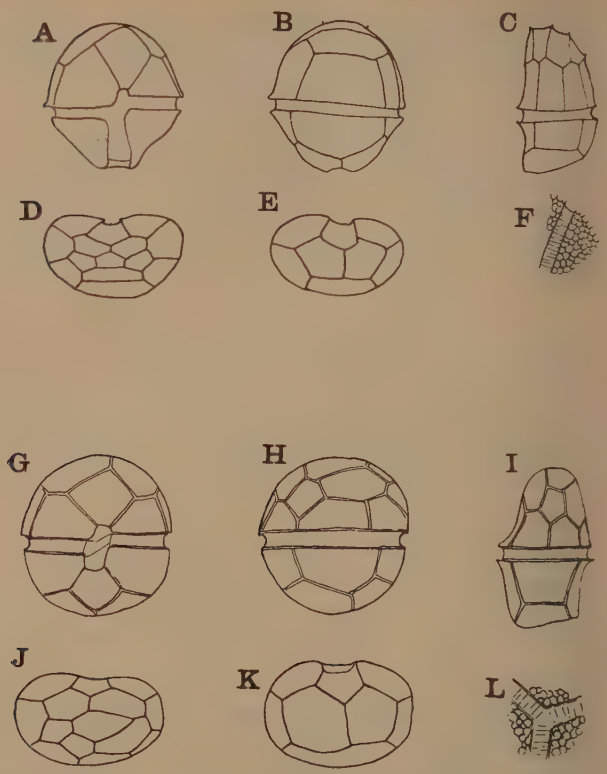


Fig. 10.—A–F, *Peridinium Willei*. G–L, *Peridinium cinctum*. All figures ×4500, except F and L, which are × about 1600.

3. Peridinium Wierzejskii Woloz. (Fig. 11, A–F.) See Schiller, 1937, p. 165.

This species is fairly common during early spring in this district in both acid and neutral ponds. The figures show the plating structure which is constant and agree closely with Wolozynka's figures. The plastids are brown, both starch and oil are present; the stigma is small and dark red. Endospores are formed.

Group B.—*Species with two accessory apical plates.*

4. Peridinium africanum Lemmermann. (Fig. 11, G–I.) See Schiller, 1937, p. 179.

The specimens figured appear to be nearest to *P. africanum*, but differ somewhat in their delicate unstriated armour. In most specimens also the intercalary bands are very narrow. The form of the antapical end varies a good deal, but nearly always has 1–4 spines. Plastids are always present and are dark brown ; no eye-spot was seen.

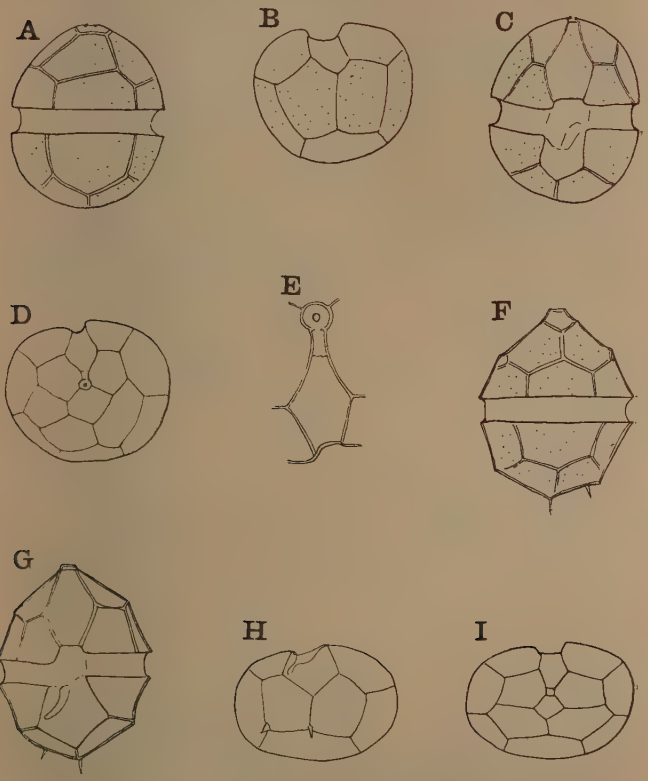


FIG. 11.—A–F, *Peridinium Wierzejskii*. G–I, *P. africanum*. All × 800 except E, the ' rhomboidal ' plate, which is × 1600.

*P. africanum* belongs to a group of about six species with an apical pore and essentially similar plating. Among these the present specimens might also be compared with *P. inconspicuum*, but differ in their larger size (36 $\mu$ to 24 $\mu$ long) and in possessing plastids.

Fairly frequent in both eutrophic and oligotrophic ponds and lakes, January to May.

5. PERIDINIUM PSEUDOLAEVE Lefèvre. (Fig. 12, E–H.) See Schiller, 1937, p. 170.

The specimen figured agrees closely with *P. pseudolaeve* except that no striations were observed in the intercalary

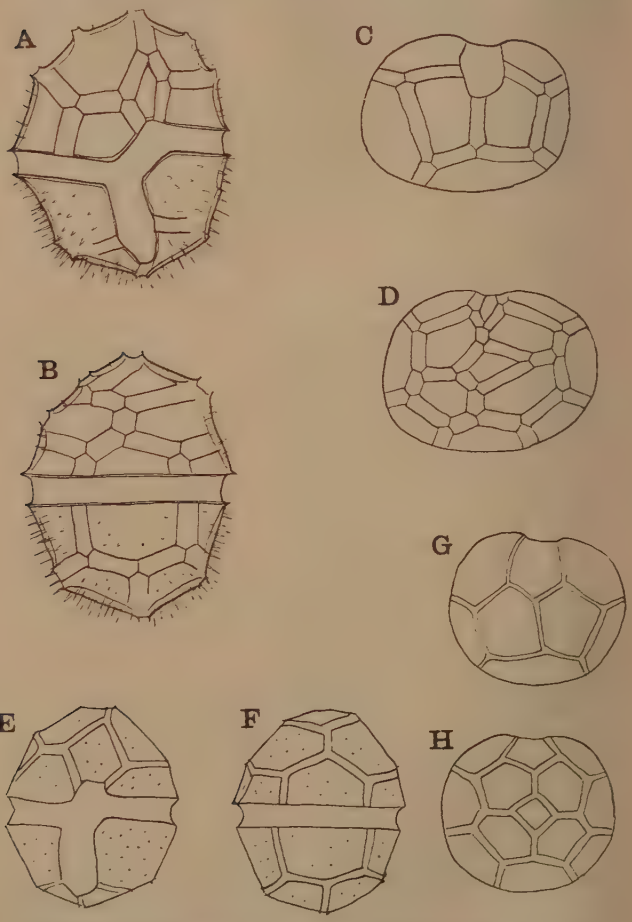


FIG. 12.—A–D, *Peridinium palatinum*. E–H, *P. pseudolaeve*. All ×800.

bands. It differs from typical *P. palatinum* (=*laeve*) in having a fair-sized rhomboidal plate and a regularly arranged apical group. Other specimens associated with this one

approached *P. palatinium* in having a rather smaller rhomboidal plate and in their larger size (48 $\mu$ long). This species is thus close to *P. palatinium*.

Found in winter plankton of one pond : forming endospores in March.

Gravel pit, oligotrophic, but not peaty, 0° 55′ 38″ W., 51° 24′ 0″ N., February and March 1936.

6. Peridinium palatinium Lauterborn (*P. laeve* Huitfeld-Kaas). (Fig. 12, A–D.) See Schiller, 1937, p. 169.

This species is common in winter and spring in ponds. It varies in size from 30 $\mu$ long (when suture plates are absent) to 48 $\mu$ long (with broad suture plates). It varies also in the development of spines, especially on the posterior end and in the concavity of its plates. The chief differences between the specimens assigned to *P. palatinium* and *P. pseudolaeve* are thus the smaller rhomboidal plate and somewhat asymmetrical apical group—differences which may not be of specific value.

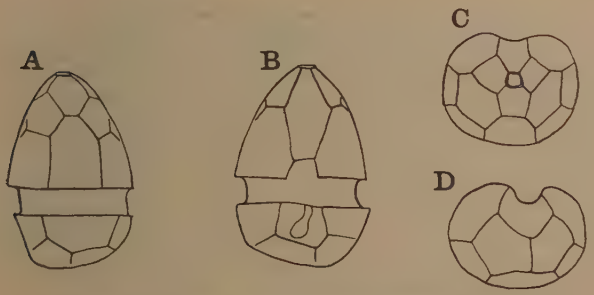


Fig. 13.—A–D, *Peridinium umbonatum*, ×1600.

7. Peridinium umbonatum Stein. (Fig. 13, A–D.) See Schiller, 1937, p. 171, for synonymy.

A small *Peridinium* (18–22 $\mu$ long) which appears to be identical with one of the forms (var. *inaequale* Lemmermann) of this very polymorphic group, is shown in fig. 13. The test is always very delicate and the sutures are narrow and hard to see ; the plastids are pale brown and there is no stigma.

Forms agreeing very closely with this have been found in a good many oligotrophic pools at all seasons. It is interesting that although some are a little more rounded and less unequally divided than the figured specimen, none showed red-brown plastids, broad sutures, strongly dotted plates or spines such as are seen in the other varieties. This suggests that some

at least of these other forms may be worthy of specific rank. From *P. pusillum*, the present specimens differ chiefly in lacking a stigma.

8. Peridinium bipes Stein. See Schilling, 1937, p. 158.

A form agreeing with this species was collected once from a permanent pond at Mortimer, but unfortunately the drawings made were not sufficiently complete to show the plate structure fully. It is rather more distinct than most species in this group, being distinguished from most by its apical pore.

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*Discussion.*—

Dr. G. P. Bidder begged Professor Harris not to be troubled if a well-known and well-recognized species is suddenly divided into thirty species and perhaps three genera solely on the measurement and outlines of its concretions. If an organism has hard parts it follows that these parts have hard outlines and exact measurements. With differences of temperature, salinity, pH., &c., at the time of deposit, those measurements and those outlines will vary infinitely, without any genetic difference in the organism. Systematists may erect new species on these differences, as they may with equal justice for *Homo sapiens* on the basis of the presence, form, and size of gouty concretions.

Mr. D. J. Scourfield said he had listened with very great interest to Prof. Harris's account of his investigations on freshwater Dinoflagellates. For some years past he had, intermittently, been examining nannoplankton organisms obtained by centrifuging pond and lake water and he could confirm what Prof. Harris had told them about the existence of a large number of apparently different forms of the smaller Dinoflagellates. Some of these were certainly devoid of chromoplasts and ingested very small algae, so that in this respect they acted as animals, although in structure they were essentially Dinoflagellates. Regarding the two flagella of these organisms he would be glad to have Prof. Harris's opinion as to their respective functions. The flagellum behind was without much doubt the propeller, but what did the one in the groove round the equator do ? Was it responsible for the rotation of the organism ?

Dt. R. Melville remarked :—It seemed fairly clear that the posterior flagellum was acting as a propeller, the same general principles being involved as in the motion of a fish using its tail fin. The exact function of the median flagellum was obscure and what took place in the median groove was a rather mysterious business. It was possible that the problem could be cleared up by the study of a working model on a suitable scale.

Prof. T. G. B. Osborn asked whether the flagellum was at the anterior or posterior end.

The President, in complimenting Prof. Harris on his haul of species, said that it was another example of how intensive—and intelligent—search in the most unlikely places added to our knowledge of organisms and their ways.

Dr. B. Barnes and Mr. H. R. Hewer also spoke.

Prof. Harris replied that the flagellum was definitely a propeller, not a tractor.

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## ON THE HISTORY OF THE ELEPHANT SEAL, MIROUNGA LEONINA (Linn.).

By J. E. Hamilton, M.Sc., F.L.S.,
Government Naturalist, Falkland Islands.

Recently I had occasion to examine some of the seals' skulls in the Royal College of Surgeons, and my attention was drawn to the upper and lower jaws of a large male Elephant Seal, no. 1111 (figured on p. 36). On reference to the catalogue the following information appeared :—

'3923. The anterior portion of the upper jaw of the great Proboscis-Seal (*Cystophora proboscidea*).

The external walls of the alveoli of the canines and molars of the right side of both jaws have been removed ; showing the great size of the root as compared with the enamelled crown, the longitudinal prominence on the outer side of the crown of the upper canine, the progressive diminution in the length of the upper molars, and the near equality in the length of the lower molars : the roots of the teeth converge slightly towards their implanted extremities in both series.

These jaws are from the original specimen brought to England by Lord Anson from the South Seas in 1744—See Anson's " Voyage round the World ", p. 122, pl. 19, where the species is called the " Sea Lion ". *Mus. Brit.*'
(Owen, 1853.)

'1111. The anterior portion of the upper and lower jaws with the teeth. O.C. 3923.

The outer wall of the alveoli of the canine and molar teeth on the right side have been removed to show their roots. These formed part of the original specimen brought to England by Lord Anson from Juan Fernandez in 1744. See Anson's "Voyage round the World", p. 122, pl. 19, where the species is called "Sea Lyon", and upon the description and figure of which was founded the *Phoca leonina* of Linnaeus. They were preserved for many years in the stuffed skin in the British Museum, from which institution they were transferred, with other osteological specimens, to the College of Surgeons in 1809. Purchased 1809.'
(Flower 1884.)

These specimens were therefore among the miscellaneous collection bought by the Royal College of Surgeons from the British Museum in 1809, a collection which included various human monsters withdrawn from the galleries lest the sight of them should induce pregnant women to give birth to similar objects. From 1814 to 1828 there was intermittent trouble over specimens which had been unintentionally transferred, and in the latter year many were returned by the Trustees and £90 refunded to the College, the original payment having been one of £175 10*s*. 0*d*.

In the MS. catalogue of the Sloane collections in the Natural History Museum, no. 1234 in the volume 'Pisc. Av. Ov. Quadrupeds' is described as 'The same [i.e. Sea Lion] of a lesser sort. An(?d) th(?e) s. lyon of the Id Juan Fernandez of the Coast of Chile in the S. Sea.' The preceding specimen is 'The head of a Morse (or Sea Lion) from Groonland'. Further, no. 1056 in the catalogue was described, with a query mark, as the skin of a sea lion, but it is not correlated with no. 1234.

Although it seems possible that the specimen under consideration may have come to the British Museum from the Sloane collection it does not agree with the account of no. 1234, which, by implication, was a complete 'head', since it is only the anterior part of the skull and mandible. The parts have both very clearly been cut from the fresh skull and dried, fragments of soft tissue can be found, and the bones have the characteristic varnished appearance caused by dried blood.

The manuscripts in the College of Surgeons throw no more light on the history of these specimens and it may reasonably be suggested that the statement in Owen's Catalogue was

derived from Clift by Owen and that of Flower in turn from Owen by word of mouth.

The Elephant Seal was first called the Sea Lyon. Linnaeus (1757) has ' *Phoca leonina* . . . . *Leo marinus* Anson itin. 100 t. 100 habitat ad polum Antarcticum ' and Anson's or rather Walter's description of this animal is based specifically on specimens seen on Juan Fernandez and it is accompanied by a very life-like figure showing both sexes, although it must be admitted that this species has not flat nails on its fore-flippers (Walter, 1748, p. 122 and plate 16). Juan Fernandez is therefore the type-locality.

Linnaeus could not have examined Anson's material, since the latter did not return until 1744 and Linnaeus visited England in 1736. His description was doubtless taken from the translation of Walter into French which was published at Amsterdam in 1751, and of which the title is included in Aurivillius's catalogue (1814).

Through the courtesy of the authorities of the British Museum library I am informed that in this work the plate of the ' sea lion ' faces page 101 and is numbered 13. I can therefore only deduce that the ' 100 t. 100 ' of Linnaeus is a clerical or typographical error for ' 101 t. 13 '.

Since, therefore, the Royal College of Surgeons' specimen, no. 1111, is from Juan Fernandez and is a contemporary of the type description, having indeed been collected when the type-material was examined, I propose that it should be considered as the type-specimen of the Elephant Seal, *Mirounga leonina* (L.).

This specimen itself measures 6·5 cm. from the anterior margin of the socket of the first upper cheek-tooth to the posterior margin of the 5th, last, tooth of the series on the left side and 5·7 cm. between the upper canines.

The corresponding measurements of skull no. 1939.5.13.1, a very large example in the British Museum, a large male, are 8·6 and 6·2 cm.

The type therefore is the skull of a large, but not fully grown animal.

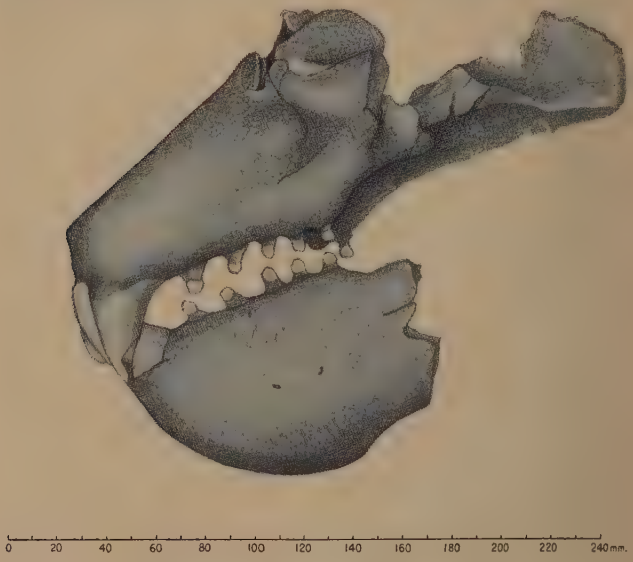
It is known that the Elephant Seal formerly had a much wider distribution, and Fraser (1935) has recorded an early account of this species at St. Helena (by P. Mundy, 1656), although his identification has been queried by Murphy (1936), who suggests that the animal may have been a Leopard Seal.

An examination of Mundy's drawing and the quotation from Dampier compel me to support Fraser.

In the drawing the seal shows the small blunt fore limb of the Elephant Seal which is entirely different from the very long and pointed appendage of the Leopard Seal.

The animal is alarmed or threatening, with deeply creased nose and open mouth, such as is typical of the female Elephant Seal which has a merely rudimentary ' trunk ', but, like the immature, displays just this creased appearance of the snout when the mouth is open. The Leopard Seal merely opens its enormous jaws and indeed the unwrinkled face of an enraged leopard seal adds to its appearance of cold ferocity. Mundy's seal lacks also the smooth profile of the Leopard Seal.

The drawing shows the ' four great teeth ' described in the text and that is exactly what one notices in the elephant seal, which indeed possesses ' four great teeth besides small '. It is incredible that a person with Mundy's enquiring mind would fail to notice the heavy rip-saw dentition of *Hydrurga*.




Type-skull of *Mirounga leonina*.

Finally, ' Sea Lyon ' was the earlier name for the Elephant Seal rather than Otariids which were ' sea-wolves ' and ' seyles ', and Dampier, who visited St. Helena in 1691 (fide Fraser), convinced himself that the animals there were ' sea-lyons ' and not manatees. ' I was informed ', says Dampier, ' that they get Manatee or Sea-cows here, which seemed very strange to me. Therefore, enquiring more strictly into the matter, I found that the Santa Hellena Manatee to be, by their shapes and manner of lying ashore on the rocks, those creatures called Sea-lyons '.

The elephant seal is migratory, and it was fairly common at Tristan da Cunha a hundred years after Mundy, and indeed lingered there until 1852 when J. MacGillivray wrote that 'elephants' were almost extinct. 'There is one place, however, on the South-east side of the island, which, in preference to others, they still visit occasionally.' It is therefore not in the least surprising to find it recorded as a visitor to St. Helena in 1656. Finally, an Elephant Seal is very much more likely to be mistaken for a Manatee than is any other pinnipede.

I would express my thanks for information and assistance to Messrs. A. J. K. Esdaile and F. G. Rendall, of the British Museum, to Dr. A. J. E. Cave, of the Royal College of Surgeons, and to Dr. F. C. Fraser, of the British Museum (Natural History).

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## A NEW APODAL LIZARD, NESSIA HICKANALA, FROM CEYLON.

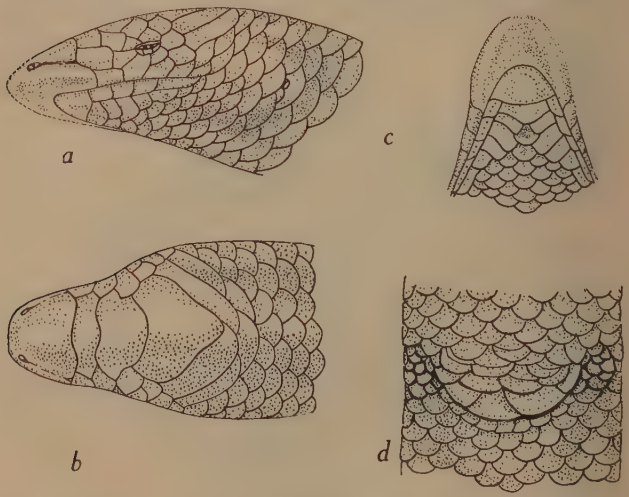
By P. E. P. Deraniyagala, M.A. (Cantab), A.M. (Harvard), F.L.S., F.Z.S.

There are six known species of the subfamily Acontiinae in Ceylon; of these two possess toes, one possesses four toeless limbs, two possess vestigial hind limbs only, and one is completely limbless. To these is now added a seventh species which is the second apodal one to be recorded from Ceylon; known from three specimens taken together at Pomparippu. Its description is as follows :—

The name 'hickanala' is the Sinhala equivalent for *Mabuya*. Habit anguiniform, apodal, with a few small scales indicating

the position of the hind limbs. Snout (see figure, *a*) very shark-like, being convex dorsally, but strongly flattened ventrally with a prominent labial ridge; jaws overshot, but front teeth not exposed. Eye small, its lower lid covered by three transparent scales, ear small, about six or seven scales behind eye which is slightly closer to nostril than to ear. Rostral (see figure, *b*) covers about three-fifths of the snout, with the nostril pierced in its anterior region and connected to the posterior margin of this shield by a groove.

Frontonasal only about a third of the length of the rostral, and about half the length of the frontal, which is shorter and




*Nessia hickanala*, sp. nov. (*a*) left semiventral view of head, (*b*) dorsal view of head, (*c*) ventral view of chin, (*d*) ventral view showing enlarged preanal scales; position of hind limbs denoted by small scales.

narrower than the interparietal. Parietals as wide as supraoculars and contiguous behind the interparietal, behind them a single transverse row of four enlarged occipitals. Supraoculars three, one large postocular. Preocular strongly enlarged, cuneiform. Supralabials four, the second subocular; mental (see figure, *c*) moderate, contiguous with a single triangular chin-shield, and with four enlarged shields along each mandible below the four infralabials, of which the last is conspicuously elongated. Body-scales directed ventrally, dorsals feebly enlarged, 20 to 21 scales around mid-body, preanals conspicuously enlarged (see figure, *d*), caudals subequal.

*Colour.*—Pinkish brown, darker dorsally, each scale-pocket a dark brown which becomes reduced with age. After death the pink is replaced by a pale grey.

*Dimensions.*—(*a*) The largest specimen, which had its tail mutilated, was 92 mm. from snout to cloaca, with a circumference of 17 mm. at mid-body. The others were (*b*) snout to ear 7 mm., snout to cloaca 68 mm., tail (tip mutilated) 36 mm., (*c*) snout to ear 6 mm., snout to cloaca 56 mm., tail (regenerated) 23 mm.

*The Type* is specimen (*b*) which will be deposited in the British Museum; the paratypes will be in the Colombo Museum.

*Distribution.*—A fossorial species, obtained in June 1939 from earth at a depth of 6 cm. under a heap of cocoanut branches at Pomparippu which is in the North Western Province and 8 kilometres from the sea coast.

*Relationships.*—This species discloses higher specialization than the others in the following respects: (i) Its flattened wedge-shaped snout and minute eye indicate fossorial adaptation. (ii) Its pholidosis reveals greater differentiation than in the other forms in the enlarged dorsals, enlarged preanals, and in the numerical reduction of its scales, for the costal count is only 20 or 21. In fossorial adaptation it is possibly on a par with *N. layardi* Kelaart, in which the snout is less specialized, although the ear-opening is lost in the adult. In pholidosis its closest relative is the two-limbed *Nessia sarasinorum* with its costal count of 22 and in being the only other species with enlarged preanals. *Nessia hickanala* differs from the other Ceylon species in its shark-like snout and low costal count. In view of its fossorial characters, and the numerical reduction and differentiation of its pholidosis, *N. hickanala* might be regarded as the most specialized member of the subfamily Acontiinae known from Ceylon. As Pomparippu is in the dry zone there is reason to think that a relatively arid environment is more conducive to such progress than one more moist.

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## PROCEEDINGS OF THE GENERAL MEETING
### 9 November 1939

Mr. J. Ramsbottom, O.B.E., M.A., Dr.Sc., President, in the Chair

The Proceedings of the General Meeting held on Thursday, 26 October 1939, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

The following Fellow signed the Obligation in the Book of the Charter and Bye-Laws and was admitted:—William Charles Osman Hill.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time, in favour of Richard Charles L'Estrange Burges, William Leslie Carter, David Noel Jones, Walter Eric James, and Mary Rebekah Lambert ; for the first time, in favour of Marian Muriel Whiting.

The President reported the death of Col. H. H. Johnston, C.B., C.B.E., a Fellow of the Society.

Sir Arthur W. Hill, K.C.M.G., F.R.S., gave an account, illustrated with lantern-slides, of ' Desert transformation in Libya '. [Printed in full below.]
The President added some comments.

Mr. Allan Eslick (Visitor) gave an account, with ilustrations, of his paper, ' An ecological study of *Patella* at Port St. Mary, Isle of Man '. (Communicated by Prof. J. H. Orton, D.Sc., F.L.S.) [Printed in full, p. 45.]

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## DESERT TRANSFORMATION IN LIBYA.

By Sir Arthur W. Hill, K.C.M.G., F.R.S., F.L.S.

Libya stretches along the north coast of Africa from Ras Agedir in the west, where it marches with Tunis, to the Egyptian frontier at the Gulf of Solum on the east. My remarks refer to the low-lying coastal region of Tripolitana, which was the part of Libya I visited when with Sir John Russell, as Government Delegates, we attended the VIIIth International Congress of Tropical and Sub-Tropical Agriculture, held at Tripoli from March 13th–17th, 1939.

Libya has undergone great changes in historic times. In classical days the country maintained a considerable population, as the ruins of the great cities, Sabratha, Leptis Magna, and others, indicate. The magnificent ruins show that they were very wealthy cities, and since there are no important mineral resources their wealth must have been derived from the soil. Homer refers to fertile Libya, for it produced wheat and olive oil, which were exported to Rome in large

quantities. Then, again, there must have been ample supplies of wood, which furnished fuel for heating the baths, which were so characteristic a feature of great Roman cities.

With the decay of the Roman occupation and during the subsequent Byzantine period, the country was left uncared for, and drifting sand gradually obliterated all marks of civilization and engulfed the great cities.

The climate of this coastal region, which the Italians are now actively engaged in colonizing, is Mediterranean in type, cool wet winters and hot dry summers. Rainfall occurs mainly from November to March ; the maximum fall is on the two horns of the Gulf of Sirte around Tripoli and Gebel-el-Achar, where it may be from 350–400 mm., and decreases rapidly as one passes inland. Within a few miles of the base of the Gulf, it is less than 50 mm. a year. The new Italian Colonies in Tripolitana are mostly situated in an area with a rainfall of 200–300 mm., while those in Cyrenaica enjoy a somewhat higher rainfall.

There are no regular rivers, but here and there deeply eroded wadis, which are torrential streams at times of heavy rainfall. Winds are strong and blow either from the sea or from the desert, carrying much sand which causes considerable discomfort and eye trouble. The general impression of the coastal district, where colonization has not yet started or only just begun, is a great sandy waste, flat or slightly undulating, with dunes of blown sand on the seaward side, often extending some way inland. To the south, low ranges of hills may be seen, and inland from Sabratha the country is more undulating, but for the most part it is a sandy waste with tufts of grass and low scrub. Here and there large groves of date palms may be seen marking an oasis, and in such places there is usually a native settlement. The sandy wastes are also interrupted now and again by large areas of asphodel indicating a heavier type of soil, which apparently is not very amenable to cultivation.

Except for a few low bushes of *Zizyphus Lotus* and acacias and tufts of Esparto and other grasses, there is nothing to break the monotony of the sandy desert country, though along the roads there has been planting of Eucalyptus, *Acacia cyanophila*, *A. saligna*, Pines, *Thuja* and *Cupressus*. These were growing well and furnished welcome shade from the sun and shelter from the blowing sand. The acacias, in full flower at the time of our visit, also serve a useful purpose as sand binders.

From a casual inspection one could not imagine a less hopeful area for development than this coastal region of Libya. It is, however, far more promising than appearances would suggest, for below the surface-covering of blown sand there

is a good, deep, fertile soil, and there is an abundant supply of underground water in two tables, one near the surface and not very abundant, and the other some 400 metres deep, abundant and under pressure. This deeper underground supply has been freely tapped and rises to the surface and may even rise in a fountain several feet high. This is used extensively for irrigation for the new villages of Crispi and Gioda, since the rainfall is inadequate for intensive agriculture, and there are no rivers which could be used for canal irrigation.

The colonization of this tract of desert country is the enterprise which the Italians started in 1923, under Count Volpi, and was further developed by Marshal Emilio de Bona and Marshal Badoglio. Now, thanks to the energy and enthusiasm of Marshal Italo Balbo, who was appointed Governor of Libya in 1933, the enterprise is an unqualified success and a remarkable achievement.

At first colonization was a private enterprise assisted by Government loans etc., and much good work was done and some irrigation was started. This 'capitalist' system, entailing the setting up of large estates, did not satisfy more recent Fascist ideals, for it did not bring in the number of peasant colonists whom it was desired to settle in the country. A new scheme was, therefore, drawn up by Marshal Balbo and approved by the Duce on demographic principles. This direct Government colonization provides for the importation of skilled agricultural peasant families as small holders with 15, 20, or more hectares of land, who will in due course become actual owners of their holdings.

Some 70,000 hectares are being reclaimed and converted into holdings, and every detail for the well-being and comfort of the new colonists and for the supervision of their agricultural undertakings has been most carefully arranged *.

First and foremost the blowing sand menace had to be overcome, and this is being successfully accomplished by fixing the sand-dunes. The principal and most effective method consists in 'planting' tufts of dead grasses,—*Imperata cylindrica*, Esparto, and other grasses—in straight lines across the dunes at right-angles to one another, the dry hedges being about 2 metres apart. The result is a chess-board arrangement all over the surface of the dunes, each 'square' being about 2 metres across, bounded by the dry hedge on the four sides, sticking up about half a metre over the surface

* For fuller accounts of the Italian Colonization Schemes and arrangements and details as to the farms and their equipment, reference should be made to the paper by Sir John Russell, 'Geographical Journal' (xciv. No. 4) for October 1939; also to 'Colonists in Libya", by Italo Balbo, Nuova Antologica, November 1938, and 'Notes on the Principles, Methods and Aims of the New Colonising Scheme for Libya'.

of the dune when first set out. A young tree is then planted in the centre of each square. *Eucalyptus rostrata*, Pines, and *Cupressus sempervirens* are the trees mainly planted on the dunes ; the *Eucalyptus* are transplanted with balls of earth, but the others are just dug up and planted, probably with some good earth, in the centre of the squares of sand. For the first two years, the small seedling trees are watered, but after that they are left to take care of themselves, and in most cases they appeared to be thriving. The dry grass hedges arrest any considerable movement of the sand and also prevent the young trees either being buried or blown away. Later, grasses and other plants colonize these stabilized dunes, followed by shrubs, and a close turf becomes established and the dune is definitely fixed.

This protection of the land to the south of the coastal sandy strip from encroaching dunes is, of course, all important for agricultural development, though on the large open expanses just being developed there is much loose sand which is blown about by the frequent high winds and must be a constant source of trouble to the new colonists, until they are able to get their farms well under cultivation.

The newest village we visited was Crispi to the south of Misurata, about 120 miles east of Tripoli. The journey by car was along the excellent coastal road made by the Italians, fringed with *Eucalyptus* and *Acacia*. Crispi, like the other towns which have been built, has been designed by a competent architect, and consists of a central square, dominated by the church, with a town hall—fitted with a cinema, a school for the children, hospital, houses for the doctor and priest, a well stocked co-operative store, and a market place, &c., all connected by open colonnades and constructed in ferro-concrete and pure white. This civic centre is on rather higher ground, and all around are the scattered farms, each consisting of 15 hectares, part of which can be irrigated, the rest being devoted to dry farming.

On the irrigated land wheat, grain crops, Leguminous crops, such as Lucerne, Beans, etc., cotton, tobacco, medicinal herbs, and vegetables, are grown, while on the dry farming area olives, vines, almonds, and pistachio, and sometimes fruit trees are planted. The trees are very widely spaced, being planted 60 ft. apart, so that each tree may have sufficient room for root development and obtain all the available water without interfering with its neighbour.

Crispi was only about 6 months old when we visited it, and looking out over the village one saw the small white farmhouses, scattered over the sandy plain, with scarcely any sign of cultivation. On closer inspection the small trees on the un-irrigated land could be discerned and somewhat meagre

crops could be seen growing on the irrigated areas, which at present amount to about 5 hectares per farm. A biting sand-laden wind did not add to the enjoyment of the prospect, either of the visitors or, one would imagine, of the newly arrived colonists! A visit next day to the older villages of Michele Bianchi and Oliveti, to the west of Tripoli, towards Sabratha, presented a very different picture. The villages have been established some two or three years on land formerly large capitalist farms, and the growth of the trees and crops was quite remarkable. All the olives and almonds were growing well and making good trees, and there were no apparent failures or replacements, while the crops of wheat, lucerne, citrus, etc., on the irrigated land were excellent. The farms here each have their own well, whereas at Crispi and Gioda, it is obtained from the deeper layer by artesian wells and distributed to the various farms by irrigation channels. When it is remembered that at the start the site of these villages was a sandy waste, similar to Crispi, the transformation of the country into a good agricultural district is a great tribute to the organizers of this great enterprise and to the industry of the colonists from the Campagna, who are deservedly proud of the result of their labours.

One thousand eight hundred colonists' houses and farms are being provided in the new villages. The house consists of three rooms, kitchen, etc., with baking oven, farm buildings —pig sty, manure store, complete equipment of tools, machinery, materials, cattle, and supplies of seed for every one of the 1800 colonist families.

The settler receives wages for the first few years until his holding begins to yield returns. He is then put on a crop-sharing basis and at the end of 5 years becomes the owner of his holding. When he becomes established he has to pay back the cost of his farm, furniture, and equipment to the Government, and this he is expected to do at the end of twenty years, when he becomes full owner of his land.

The Scientific services, which are admirably arranged are under the general direction of Professor Armando Mangini of Florence and the excellent Agricultural Experiment Station is under Dr. Giulio Vivoli—Dr. Ettore Ducross being in charge of Zootechny. The fine collection of Citrus, in full fruit, and other cultures, as well as the newly-built laboratories, were of great interest.

# AN ECOLOGICAL STUDY OF PATELLA AT PORT ST. MARY, ISLE OF MAN.

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[Communicated by Prof. J. H. Orton, F.L.S.]

An ecological investigation has been made of the forms of the genus *Patella* on a reef at Kallow Point, Port St. Mary, I.O.M. E. Fischer-Piette (1935), in recent studies of the genus, has summarized the characters differentiating *P. depressa* Pennant *, *P. intermedia* Jeffreys, and *P. vulgata* Linn., and as Orton (1929) has recorded shells of the '*depressa*' type from pools it was decided to investigate the characters of all the limpets in and about a given pool.

## Taking the sample.

*Habitat.*—The habitat (see fig. 1, p. 46) is a blunt foreland running SE. between Perwick Bay and Port St. Mary Bay, composed almost entirely of rocks between high- and low-water marks; at the end of the point these latter are some 100 yards apart. The geological formation is a bed of hard, slate-coloured Carboniferous limestone tilted at a gentle (10°) angle from the horizontal and running downwards in a S.S.W. direction. The strata are eroded to expose free edges two or more feet in thickness and extending considerable distances from WNW. to ESE. The formation has earned the title at the Biological Station of 'the Ledges'.

The Ledges are rather poorly vegetated at the upper levels, doubtless due to their exposure to the prevailing SW. gales and to the fact that the smooth, nearly horizontal slabs do little to break up the incoming waves. In many places at these levels a considerable percentage of the surface area is quite untenanted.

Limpets are very abundant at all levels down to the *Laminaria* zone near low water. Between half-tide and low water barnacles cover nearly all the surface not occupied by limpets. *Lithothamnion* encrusts the basins of rock pools of which there is a fair number at all levels from low- almost to high-water springs, and extends over the drainage areas from pools and much of the open rock area at low-water springs.

* As mentioned recently by Fischer-Piette (1938), J. R. le B. Tomlin (1923) has established that *P. intermedia* Jeffreys, 1865, is equivalent to *P. depressa* Pennant, 1777, leaving the '*P. depressa*' of this paper (= *P. athletica* Bean, 1884) as *P. aspera* Lamarck, 1819. This latter name is not used here to avoid confusion. For the same reason '*P. intermedia*' is retained instead of *P. depressa* Pennant.

Fig. 1.—The special area looking east. The ' free water ' may be seen, and a ' drainage stream ' appears as a [illegible] ' dry area '. *Cf.* fig. 2.

From preliminary investigations, during which several hundred limpets were lifted from every type of situation, it appeared that *Patella vulgata* was common everywhere, especially above half-tide level, while *P. depressa* was limited to the lower levels and rock pools, occurring in the latter even near high-water mark.

*The special area* (see fig. 1).—The area from which the sample was taken for study was specially selected ; it measures 2 by 2½ metres and included a variety of habitats. It is slightly below the half-tide mark, and in calm weather is uncovered for about 5½ hours during each tide. The rock slopes gently to seaward, so that when the waves are of any magnitude the time of exposure is reduced.

The special area included (*a*) a large, shallow pool about 2 to 4 cm. deep, (*b*) various ' wet areas ' continuous with and barely above pool level, (*c*) tracts where pool water oozed gently over the rock in a ' drainage stream ', (*d*) numerous lesser pools a few cm. across, and, finally, (*e*) a considerable comparatively ' dry area '. Of the ' dry area ' very nearly all not occupied by limpets was barnacle covered. In the ' drainage streams ' and the large pool, also to some extent in the ' wet areas ' the surface of the rock was crusted with *Lithothamnion* ; the large pool contained several patches of *Corallina* sp. in which no limpets could be found.

Thus a site was chosen to include both ' dry ' and water-covered areas, together with areas of intermediate condition ; it was well known both before visiting the area and as a result of preliminary inspection that the pool would harbour most of the *P. depressa* type of limpet, while that on the dry parts *P. vulgata* would predominate.

*Procedure.*—The area was accurately marked out in half-metre squares with a grid of white tapes, and later with lines scored on the rock. Bird's-eye photographs were made possible by using a tripod constructed specially for such views by Messrs. J. R. Bruce and H. B. Moore. Vibration due to the wind was much reduced by adding bracing-cords, which unfortunately were included in the camera's field of view. The shutter was released by a delayed-action device attached to the usual ' Antinous ' release, the device itself being mounted in a wooden holder screwed to the tripod head, and being started by pulling a stout thread from the ground. Any vibration occasioned by the pulling had ample time to cease before the delay-device operated the shutter.

Squares drawn to scale on paper enabled a map of limpet distribution to be drawn (see fig. 2, p. 48) from viewpoints vertically above each square. Each limpet was given an identity number and its position recorded, the area being closely scrutinized to ensure that all limpets were collected.

Fig. 2.—Distribution of limpets in the special area. Solid circles = *P. vulgata*. Triangles = *P. depressa*. C = *Corallina* sp. D = 'dry area'. DS = 'drainage stream'. FW = 'free water'. W = 'wet area'. *P. vulgata* (618 individuals) occurs mainly but by no means entirely on the drier parts, while *P. depressa* (280 individuals) is more strictly confined to the more moist places.

In all there were 911 individuals, giving a population density of 182 limpets per sq. metre.

The limpets were placed in numbered paper bags wetted with sea-water, packed in baskets, and stored in an unheated room. Under these conditions limpets easily survived for a fortnight, whereas specimens kept upside-down in shallow dishes of sea-water showed a 50 per cent. mortality in two days, the nuchal cavity becoming charged with faeces.

### Analysis of the sample.

The animals were laid out upside-down in a shallow dish of sea-water. In nearly every case they became active, extending as far as possible from their shells and vigorously exploring their surroundings in an endeavour to obtain foothold and so right themselves. Advantage was taken of this behaviour to see and record (i) colour of sole of foot and the periphery, (ii) colour of mantle lobes and tentacles, and (iii) colour of cephalic tentacles. The length of the shell was then determined with a Vernier gauge.

Exposing the loop of the radula a smooth instrument was inserted in the loop and a gentle outward pull applied, whereon the growing end of the radula was pulled from its sheath and the radula straightened out. Provided all jerkiness was avoided, the anterior, oval end of the radula, with its transparent, horny flanges could be torn from its position with forceps without fracture. The length was measured by laying the radula on a small, stainless-steel rule, the value being recorded to the nearest half millimetre.

Several radulae were dissected out complete with sheaths, and the forcible extraction of the growing end from the club-shaped end of the sheath was performed under a microscope with micrometer eyepiece. It was found that a small amount of radula remained behind in the sheath, but not more than about one radula-width, i.e. about 1 mm. in a large specimen, or about 2 per cent. of the total length. It was felt that the slightly reduced length-value obtained by the method described above was a sufficiently constant proportion of the true length, which would be about 2 per cent. greater and obtainable only at considerable inconvenience.

The radulae were examined for dentition characteristics as described below, and the following internal details of the shell recorded :—(i) Nature of nacre; (ii) Stain (if any) imposed on nacre; (iii) Colour of 'spatula' (the apical region enclosed by the adductor-muscle scar corresponding to the visceral hump and nuchal chamber). Later, breadth and height of shell were measured, the latter being determined by a specially constructed instrument. The shell was placed with its base resting on a blunt ridge at right angles to the

longitudinal axis of the shell, and a graduated slide was lowered on the apex. This procedure was adopted in preference to placing the shell on a plane surface, as by the latter method the longitudinal concavity of the shell margin frequently present gives a false reading.

One hundred specimens were examined in detail as noted above. A rapid analysis of the remaining 811 was made later.

*Analysis of the 100 specimens.*—It was found that the animals fall very definitely into two distinct groups, corresponding to *P. vulgata* Linn. and *P. depressa* Pennant. The remaining British type, *P. intermedia* Jeffreys, was not found. Two characters permit of more or less absolute distinction of these forms, namely the pigmentation of the mantle papillae and the dentition of the radula.

In *P. vulgata* the pallial tentacles are always a weak, translucent grey to grey-white. In *P. depressa* they tend to be charged with an opaque, stronger white colour. In some animals the pigment is present throughout the length of all the tentacles ; in others it may be restricted to the middle or terminal half, and be near to vanishing point in some of the tentacles, but it was always possible to find a fair percentage of the tentacles bearing a recognizable white. The translucent grey-white of some *P. vulgata* was never to be confused with a weakly pigmented *P. depressa*.

This basis of distinction is given by Dautzenberg and Durouchoux (1906, p. 12) as applying to the separation of *P. vulgata* and *P. intermedia* Jeffreys, the latter having the white tentacles as in *P. depressa*. Fischer-Piette (1935, p. 18) confirmed this and showed the presence of white tentacles in *P. depressa* also. However, in 1853 Forbes and Hanley (1853, II, p. 428) had quoted and confirmed the observations of a Mr. Clark on *P. depressa* (=*P. athletica* Bean) : ". . . . the animal differs specifically from *vulgata* ; . . . . the mantle is edged with flaky-white, jointed filaments . . . .".

The radular teeth, as discovered by Fischer-Piette (1934 *a*), afford a criterion of distinction which is even more rigid for our specimens.

Apart from these two features there are many other general characters offering discrimination between the two types. The colours of foot and mantle in *P. vulgata* are of ochreous-yellow cast, darkened to varying degrees with smoky hues, the general impression being sombre and muddy. In *P. depressa* the foot itself varies from a slightly pinkish-cream through creamy-peach, peach, and orange-peach to a brilliant and full orange ; the mantle does not quite attain the orange end of this range. Always there is a trace of pink which is quite absent from *P. vulgata*, as is the general paleness and delicacy of the tinting. The largest specimens of *P. depressa*

tend to be the most richly coloured. After seeing a fair number of specimens one felt confident, on this colour basis, of distinguishing with a high degree of certainty the type of any particular limpet as shown by the pallial tentacles and radula.

The shells according to the older authors, e.g. Forbes and Hanley (1853), can be distinguished by the more crowded and more denticulate carination. This was found to be by no means apparent in every case, and often the ridges on the shell were worn off. However, it is true in many cases that the outline of *P. depressa* is elongated and tapered towards the anterior end, to which the apex often approximates itself, while in *P. vulgata* the shell is usually more nearly circulo-elliptical in outline with subcentral apex.

The nacre of the shells is nearly always a rich milky white in *P. depressa*, contrasting with the transparent nacre of the typical *P. vulgata* shell. In both types there is always a bluish iridescence. Exceptions to the milkiness of nacre were usually in the smaller examples of *P. depressa*.

*Length of the radula.*—That the length of the radula in *P. depressa* is only about one half that of *P. vulgata* or *P. intermedia* had been noted by Dautzenberg and Durouchoux (1906, p. 13). Fischer-Piette (1934 *a*, p. 280), to obtain a measure eliminating approximately the size variation of different animals, divides the radula length by the length of the shell, so obtaining what for convenience will be referred to as the 'radular fraction'. He gives (1935, p. 19) the means and extremes for forty specimens of each type, as follows :—

*Radular fractions.*

| | Means. | Extreme values. |
|---|---|---|
| *P. depressa* ..... | 1·15 | ·95–1·4 |
| *P. vulgata* ..... | 1·75 | 1·3 –2·3 |
| *P. intermedia* ..... | 2·10 | 1·6 –2·5 |

Fischer-Piette points out that the values overlap but that *P. depressa* can be distinguished from *P. intermedia*. Combining this fact with Dautzenberg's observations of "papilles blanches sur le bord du manteau" in *P. depressa* and *P. intermedia* only, he produces the following key to the three species :—

No white tentacles visible on the edge of the mantle ..... *P. vulgata.*

White tentacles on edge of mantle.

Ratio $\frac{\text{Radular Length}}{\text{Length of Shell}}$ between ·9 and 1·4 ... *P. depressa.*

between 1·6 and 2·5 ... *P. intermedia.*

The radular fractions for the 100* specimens are shown

* As seven individuals had broken shells their radular fraction could not be calculated; the table mentioned deals therefore with only ninety-three individuals.

below. All above the critical value of 1·6 come from limpets with colourless pallial tentacles, thus ruling out the presence of any *P. intermedia* :—

| Radular fraction. | No. of individuals. | |
|---|---|---|
| | *P. vulgata.* | *P. depressa.* |
| ·9– ·99 ..... | — | 6 |
| 1·0–1·09 ..... | — | 12 |
| 1·1–1·19 ..... | 2 | 8 |
| 1·2–1·29 ..... | 4 | 1 |
| 1·3–1·39 ..... | 10 | — |
| 1·4–1·49 ..... | 19 | — |
| 1·5–1·59 ..... | 16 | — |
| 1·6–1·69 ..... | 5 | — |
| 1·7–1·79 ..... | 5 | — |
| 1·8–1·89 ..... | 3 | — |
| 1·9–1·99 ..... | 1 | — |
| 2·0–2·09 ..... | 1 | — |
| | 66 | 27 |
| Means ..... | 1·51 | 1·05 |
| Extreme values..... | 1·13–2·00 | ·93–1·25 |

*Note.*—Seven individuals not included above because of broken shells, etc. Radular lengths and therefore fractions are c. 2 per cent. too low.

In order to investigate whether the quite considerable variation in radular fraction bore any relationship to absolute size correlation graphs were constructed for *P. vulgata* and *P. depressa* respectively. From the even scattering on both graphs one may assume that there is no simple relationship of radular fraction to size or age.

*The radular teeth.*—The teeth on the radula of all *Patellae* are in transverse sets each of which is composed of three groups of teeth and two isolated ones.

While the marginals and laterals yielded no criterion of distinction, Fischer-Piette (1934 *a*, 1935) found the 'pluricuspid' teeth to show constant differences in size, shape and disposition of the cusps corresponding to each species of *Patella* as defined on other criteria. Here we are concerned only with the three British types—*P. vulgata*, *P. intermedia* and *P. depressa* *.

As the pluricuspid teeth make an angle of about 60° with the radula, a direct view downwards on the latter would give an almost end-on view of the cusps. The radula must be curved with the teeth outwards and viewed almost tangentially so that one may see the pluricuspid from the side. Fischer-Piette curved the radula under water, fixing the free

* In some regions, including the Isle of Wight and the Basque coast of France and Spain, these species occur with a complete series of intermediate forms. In those regions the pluricuspid according to Fischer-Piette (1935, p. 62) shows intermediate forms along with the various other characters.

ends with small blocks of lead (1935, p. 21). It was found more rapid to lay out the fresh radula, wetted with sea-water and teeth uppermost, on a small rectangle of paper about 3″ by 2″, and then to fold both paper and radula, with the latter exposed in a curve on the outside. The mount, held with two fingers on a microscope stage, offered a sufficiently clear view of the pluricuspids without the trouble of viewing under water.

As Fischer-Piette points out, it is necessary to fix on some constant position on the curve of the radula if comparable views are to be obtained. His system was adopted, namely of selecting for examination the pair of pluricuspids situated so as to be viewed as tangentially as possible without being obscured by the pair in front, i.e. the last unobscured pair as one passes from a normal to a tangential view.

Fischer-Piette (1934 *a*, 1935) has described the various pluricuspids, and in the three British species (*P. vulgata*, *P. intermedia* and *P. depressa*) he found three cusps in a row on each tooth. The innermost (with respect to the centre-line of the radula) was always much the smallest; in *P. vulgata* and *P. intermedia* the central cusp was largest, always being considerably larger than the outer, whereas in *P. depressa* it was either subequal to or a little smaller than the outer. Again, the axes of outer and median cusps, parallel in *P. vulgata* and *P. intermedia*, converge distally in *P. depressa*.

The teeth of *P. vulgata* and *P. intermedia* were distinguished from one another by the convexity of the sides of the median cusp in the latter, giving the cusp a blunt appearance; in *P. vulgata* the cusp was straight-sided and acute. Fischer-Piette's typical pluricuspids are indicated in fig. 3 *a* ($V_1$ and $I_{18}$) and fig. 3 *b* ($D_{10}$). The cusps of *P. depressa* are seen to be the most complicated in shape. Diagrams in fig. 3 *a* and *b* indicate approximately the various types encountered in the analysis of the hundred specimens. It will be seen that there is a most obvious distinction between the *P. vulgata* and *P. depressa* types no matter which variations of each are considered. In the *P. vulgata* types the chief variation is in the proportion which the outer cusp bears to the median. Types $V_{1(18)}$ (three examples) and $I_{18(V_1)}$ (one example) are interesting stages of approach to the *P. intermedia* type. Type $V_{(Special)}$ occurs in three examples of *P. vulgata*, all very small and presumably young limpets. The tooth has unduly tall outer and median cusps, with slightly convex sides. Their axes are slightly divergent distally. The inner cusp is very large and approaching parallelism with the others. Most interesting, however, is the presence of a distinct, small, outermost fourth cusp. One example of $V_{2(19)}$ and one of $V_{1(2)}$ bear a similarly situated but very small fourth cusp, and these are larger animals.

The variations in the *P. depressa* type are chiefly small and rather subtle changes in proportion. However, type $D_{21}$ (four examples) and $D_{21(13)}$ (one example) are notable in having a small fourth cusp similar to those mentioned above in *P. vulgata*.

Subsequently twenty-five adults of each type (not from the original sample) were specially examined. The radula of each was pressed, teeth downwards, on to a damp cloth, in order

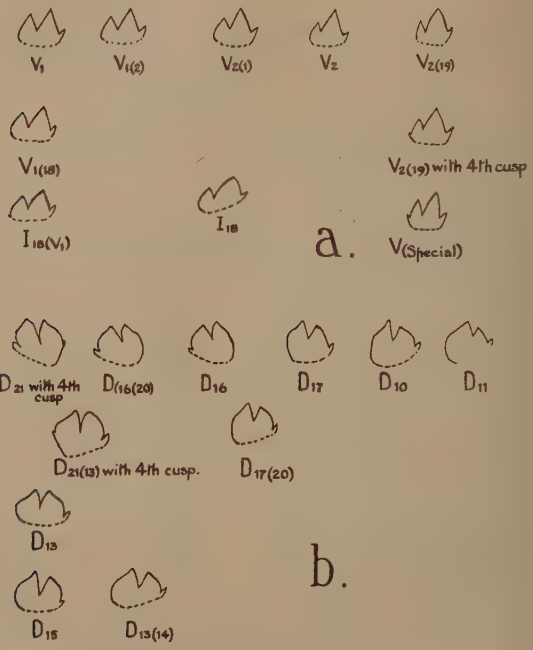


FIG. 3.—Outlines of pluricuspid teeth showing variations in **a**. *P. vulgata* and **b**. *P. depressa*, at Kallow Point. Type $I_{18}$ is from *P. intermedia* after Fischer-Piette. The closest approximation examined at Port St. Mary is type $I_{18(V_1)}$ from an individual of *P. vulgata*.

to push back the flesh from the bases of the pluricuspids; by this means it was possible to show that some trace of a fourth cusp is present in all limpets of *P. vulgata* and *P. depressa* types. The necessity for exposing the pluricuspid base and for obtaining a view of the tooth from precisely the necessary angle prevented this conclusion being reached during the original examination of the 100 limpets.

The remainder of the sample was examined at Liverpoo lin shallow dishes of sea-water and inspected for type—*P. vulgata* or *P. depressa*. Colouration of foot, mantle, pallial tentacles and nacre were used as significant characters. In spite of numerous moribund examples, due doubtless to confinement during the journey to Liverpool, it was felt that the assignment of a letter V (*P. vulgata*) or D (*P. depressa*) to each limpet was done with a high order of accuracy.

*Distribution of the whole sample.*—The Special Area was dealt with as including five types of surface (see p. 47). Fig. 2 shows these areas and the limpets thereon; nine animals are not shown for various reasons. In counting the number of each type in each area border-line cases between dry and wet areas have been assigned to the latter. The population in each area is given below :—

| Habitat. | Free water. | Drainage streams. | Small pools. | Wet areas. | Dry areas. | Total. |
|---|---|---|---|---|---|---|
| *P. vulgata*.... | 42 | 45 | 18 | 29 | 484 | 618 |
| *P. depressa* .. | 124 | 59 | 19 | 18 | 60 | 280 |
| Total..... | 166 | 104 | 37 | 47 | 544 | 898 |

As percentages of the total population of their respective areas :—

| | | | | | |
|---|---|---|---|---|---|
| *P. vulgata* ... | 25 | 43 | 49 | 62 | 89 |
| *P. depressa*... | 75 | 57 | 51 | 38 | 11 |

From fig. 2 and the foregoing figures it is at once apparent that in the whole area there are many more *P. vulgata* than *P. depressa*. There is a marked tendency for *P. depressa* to be most abundant in the large pool and wetter places and for *P. vulgata* in the drier habitats.

## The characters of young individuals.

Having found that the adult limpet population at Kallow Point can be resolved into two groups, *P. vulgata* and *P. depressa*, twenty-five of the smallest individuals of each type were examined in the laboratory, to ascertain whether the types are distinct in the young animals. They were taken from a variety of habitats, outside the special area, as follows :—

| Habitat. | Number examined. *P. vulgata.* | Number examined. *P. depressa.* |
|---|---|---|
| Half-tide level and below on open rock ..... | 10 | 10 |
| Pools and 'drainage streams' a little above half-tide ..... | 10 | 10 |
| Extreme upper limit of occurrence. (High-water neaps for *P. vulgata;* and a little lower, in pools, for *P. depressa.*) ..... | 5 | 5 |

The general colour differences between the types previously observed in the adults stand, except that the young *P. depressa* are paler than the adults; the whiteness of the mantle papillae in this type is normal.

The radular fractions obtained lie within the ranges previously found for the adults :—

| | *P. vulgata.* | *P. depressa.* |
|---|---|---|
| Extreme values ..... | 1·13–1·52 | 1·00–1·20 |
| Means ..... | 1·25 | 1·08 |

In all the radulae a small fourth cusp was present, becoming proportionally larger as the shell-length diminished below 1 cm., and approaching the size of the innermost cusp. The $V_{(Special)}$ pluricuspid was very common, but proved to be merely an early stage for *P. vulgata* and not a common basis leading to both *P. vulgata* and *P. depressa*. The pluricuspids were always distinctly of two types; the inner cusps in these small specimens had the characteristic outline of their types, acute and straight-sided in *P. vulgata* and obtusely sublanceolate in *P. depressa*.

It would therefore appear that the limpet population at Port St. Mary comprises two distinct stocks, corresponding to the accepted species *P. vulgata* and *P. depressa*.

My sincere acknowledgments are due to Professor Orton, D.Sc., who suggested the investigation; to Mr. J. R. Bruce, M.Sc., Naturalist-in-Charge at the Port Erin Station, for the loan of much field apparatus; to Mr. R. Winckworth, M.A., F.L.S., and Mrs. N. F. McMillan for loan of literature; to the Challenger Society for financial assistance; and to my colleagues at the University of Liverpool, Messrs. I. C. Jones, S. H. Jones and H. C. Davies, whose assistance rendered the field-work possible. The work was carried out while holding the Herdman Scholarship and the Edward Forbes Exhibition.

## Summary.

1. After a preliminary investigation of the rocky shore at Kallow Point, Port St. Mary, I.O.M., an area 2 by 2½ metres was selected for special study. The whole limpet population was removed for examination, the position of each individual being marked on a map of the area.

2. One hundred of these were examined in detail for dimensions, colouration and radula characteristics.

3. With copious reference to the work of E. Fischer-Piette it was found that two distinct types of limpet were present, corresponding to *P. vulgata* Linn. and *P. depressa* Pennant. No intermediate forms were found.

4. Values of the fraction $\frac{\text{Radular Length}}{\text{Shell Length}}$ were more or less as found by Fischer-Piette. Investigations as to its possible connection with age or size gave negative results.

5. The taxonomic significance of the radular dentition is indicated, and some interesting new types introduced. The tooth termed 'pluricuspid' by Fischer-Piette is shown to possess a fourth cusp in both *P. vulgata* and *P. depressa* in addition to the three principal cusps described by this worker. The fourth cusp, conspicuous in young limpets, dwindles almost to vanishing point at maturity. A fourth cusp is mentioned by Fischer-Piette only in the exotic *P. safiana*.

6. The remainder (c. 800) of the limpets were resolved into the two species by external examination, and a distribution map prepared, which showed how *P. vulgata* was most abundant in the drier parts and *P. depressa* in the pools and moist places.

7. Investigations of very young limpets showed that, while possessing rather special radular dentitions, they were nevertheless as clearly of two types as the adults.

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*Discussion.*—

Captain C. Diver said that Mr. Eslick was doing useful work in helping to clarify the taxonomic status of the species in this difficult genus by the consideration of ecological as well as purely morphological characters. But what he considered even more important was that Mr. Eslick had made a detailed study of a mixed natural population. Our knowledge

of population structure was still rudimentary, and he hoped Mr. Eslick would continue his work in this complicated field. He suggested that a better method than that outlined of comparing the ranges of tolerance of the two components of this population would be to compare the real densities of each species (in terms, say, of sq. cm. per limpet) for each type of habitat delimited. From what was known of the behaviour of limpets he did not feel sure that at the densities here considered the two species were in real competition; and in considering their distribution in relation to habitats it was of the highest importance to try to establish at what level the factor of competition entered in different sets of circumstances.

Dr. R. Melville enquired whether Mr. Eslick could say what type of rock occurred on the shore where the observations were made. In his recollection Dr. Fischer-Piette had found intergrading between the species of *Patella* in areas where there were limestone rocks. This suggested that the calcium ion was in some way connected with the intergrading. He had noticed from the pictures thrown on the screen that both the angle between the axes of the two principal cusps of the radular teeth and their relative heights differed in the two species discussed. These characters could readily be measured, and would lend themselves to mathematical treatment; had Mr. Eslick considered this possibility? The fact that no correlation had been found between several characters of the animals and their different habitats, but only between the characters and the groups regarded as species, was a confirmation of the view that the groups were in fact good species.

## PROCEEDINGS OF THE GENERAL MEETING
### 23 November 1939

Mr. J. Ramsbottom, O.B.E., M.A., Dr.Sc., President, in the Chair

The Proceedings of the General Meeting held on Thursday, 9 November 1939, having been circulated, were taken as read and confirmed.

A list of names of those who had made gifts to the Library since the previous meeting was read and laid on the table.

Certificates of recommendation of the following candidates for Fellowship were read :—For the second time, in favour of Marian Muriel Whiting ; for the first time, in favour of Sir Geoffrey Evans, C.I.E., and Walter John Zimmer.

The following candidates were balloted for and elected Fellows :—Richard Charles L'Estrange Burges, M.A., M.B., B.C., William Leslie Carter, Walter Eric James, David Noel Jones, M.Sc., Mary Rebekah Lambert, M.A., and John Walter Guerrier Lund, M.Sc., Ph.D.

The President reported the deaths of Dr. T. L. Prankerd, F.L.S., and Professor Dr. Eduard Fischer, F.M.L.S.

Dr. Isabella Gordon gave an account of her paper, ' On some species of the genus *Elamena* (*s.s.*) (Crustacea, Decapoda) '. [Printed on p. 60.]
Dr. W. T. Calman added some comments.

Mr. A. D. Cotton, O.B.E., on behalf of the author, gave an account of Dr. A. F. El-Helaly's paper, ' The effect of *Rhizoctonia Solani* Kühn on the germination of Lettuce seed at somewhat high temperatures '. [Printed on p. 78.]
A discussion followed, in which Dr. B. Barnes, Dr. Margaret Brett, and the President took part ; Mr. Cotton replied.

Miss E. R. Saunders gave an account of her paper, ' The significance of the unique floral construction characterizing a little known member of the Primulaceae—*Pelletiera verna* A. St. Hil.'. [Printed on p. 96.]
A discussion followed, in which Sir Arthur W. Hill, Mr. J. S. L. Gilmour, Dr. L. Richmond Wheeler, and the President took part ; Miss Saunders replied.

# ON SOME SPECIES OF THE GENUS ELAMENA (S.S.) (CRUSTACEA, DECAPODA).

By Isabella Gordon, D.Sc., Ph.D.,
Zoology Department, British Museum (Natural History).

(With 10 figures)

## Introduction.

There is some difference of opinion regarding the systematic position of the family Hymenosomatidae *, to which the genus *Elamena* belongs. Some authors, following H. Milne-Edwards, have placed the family in the Brachyura Catometopa near the Pinnotheridae or the Mictyridae (*e. g.* Alcock, 1900 †, p. 282). Most recent authors, however, have followed de Haan (1839 ‡, p. 75) and Ortmann (1893 §, p. 31) in referring it to the Oxyrhyncha, alongside the Maiidae.

We are at present very far from possessing a clear knowledge of the species referred to this family ‖. The descriptions and figures of many of the older authors are a constant source of difficulty and the identity of numerous species described in the earlier half of the nineteenth century remains obscure. The confusion is accentuated by differences of opinion regarding the genera (Kemp, 1917, p. 244). The truth of this statement is borne out by the fact that Tesch (1918), who studied the 'Siboga' material at the same time as Kemp was working on the Indian Museum Collection, arrived at conclusions that are often at variance with those of Kemp. For example, Tesch retains the genera *Hymenicus* Dana and *Trigonoplax* H. Milne-Edwards, while Kemp regards the former as a synonym of *Halicarcinus* White and the latter as, at most, a subgenus of *Elamena* H. Milne-Edwards.

Although fully aware of the inadequate state of our knowledge of the genus *Elamena*, Tesch gave a key to the determination of eleven species, based largely on differences in the chelipeds and the shape of the carapace. Of these species, Kemp synonymizes *E. kirki* Filhol with *E. producta* Kirk and refers *E. filholi* de Man to the genus *Rhynchoplax*, *E. pilosa* A. Milne-Edwards to the genus *Halicarcinus*, while of *E. minuta* A. Milne-Edwards he says 'whatever it may be [it] is certainly not an *Elamena*' (Kemp, 1917, p. 250). The

* Hymenosomidae Ortmann (1893, p. 31) *et auct.*; Hymenosomatidae Kemp (1917, p. 243).

† Alcock, 1900, Journ. As. Soc. Bengal, lxix, pp. 279–456.

‡ de Haan, 1833–1850, Siebold's Fauna Japonica, Crustacea.

§ Ortmann, 1893, Zool. Jahrb. Syst. vii. pp. 23–88.

‖ Some fifty-eight of fifty-nine species have been described to date.

genus, which now comprises 8–10 species, is badly in need of thorough revision, but this could not be attempted without a re-examination of such type-specimens as are still in existence. Unfortunately only five species * of the genus *Elamena* (s.s.) are represented in the British Museum Collection; and I have also been able to examine cotypes of *E. gracilis* Borradaile. A careful comparison of these species shows, however, that they differ quite appreciably from each other, especially as regards the abdomen and first pleopods of the male. I have thought it advisable, therefore, to publish some notes and figures so that future workers on the family Hymenosomatidae may give more attention to these characters.

Of the species dealt with below, there can be no doubt as to the correct determination of *E. gracilis* Borradaile (cotypes examined), *E. sindensis* Alcock from Karachi, and *E. mathaei* (Desmarest) from the Red Sea. The specimens from the Great Barrier Reef referred provisionally to *E. truncata* may prove not to agree with specimens of that species from Japanese waters. As far as I have been able to judge, they are more likely to prove identical with *E. truncata* than the specimen from Abrolhos for which a new specific name is proposed (see *E. albrolhensis* on p. 70).

In division 3 of his key, Tesch (1918, p. 20) distinguishes *E. truncata* from all the succeeding species, because the front is ' truncate ', not ' shortly triangular '. Of the species that I have examined only *E. sindensis* and *E. gracilis* seem to me to have the front shortly triangular. Owing to variation within certain species, however, such a distinction is not very satisfactory.

So far as I have been able to determine, the male abdomen in each species examined comprises five pieces, but the two distal sutures are often faint and difficult to observe (see Kemp, 1917, p. 273, and Chopra and Das, 1930, Rec. Ind. Mus., Calcutta, xxxii, pt. iv. p. 427).

I take this opportunity of re-describing and re-figuring the type-specimens of ' *Elamena* ' *whitei* Miers because Miers' original description and figure are inadequate. The species, however, does not belong to the genus *Elamena* and I have referred it to *Hymenicus* Dana, which is a synonym of *Halicarcinus* White.

I agree with the view expressed by Kemp (1917, p. 274) and others that the genus *Trigonoplax* can only be regarded as a subgenus of *Elamena*. Tesch states that ' the absence of a septum between the antennulae ' is characteristic of the genus *Trigonoplax*, but it is obvious that he is referring to the vertical plate or keel (*k*) on the ventral surface of the

* *E. whitei*, which is really a *Halicarcinus*, included.

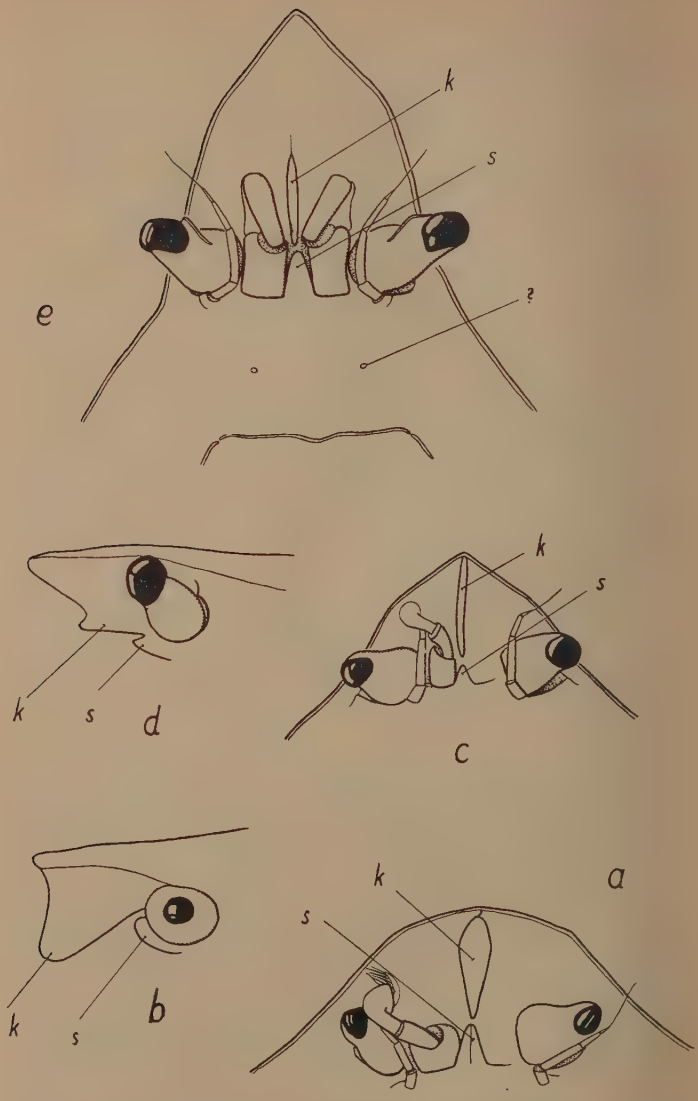


FIG. 1 *a*, *b*, *Elamena mathaei* (Desmarest), ♂. Rostrum in ventral and in lateral aspects. *c*, *E. gracilis* Borradaile, ♂ cotype. Rostrum in ventral aspect. *d*, *E.* (*Trigonoplax*) *unguiformis* de Haan, ♀, from Singapore. Rostrum in lateral aspect. *e*, *E.* (*Trigonoplax*) *unguiformis* de Haan, ♂, from Inland Sea, Japan. Rostrum in ventral aspect ; the opening of the antennal gland is not clearly visible. All × 16.

*k*, vertical keel on ventral surface of rostrum ;
*s*, inter-antennular septum.

rostrum, not to the inter-antennular septum (*s*) (fig. 1 *a–e*). The latter is present in both *Trigonoplax* and *Elamena*, but is very short and is sometimes difficult to detect until the antennules are pushed apart. The rostral keel is very deep in all the species of *Elamena*, s.s., that I have examined ; it extends right forward to the anterior margin of the rostrum and, in some specimens of *E. truncata* at least, may be visible in dorsal aspect. Owing to the presence of this vertical keel the rostrum, in frontal aspect, is as Kemp has pointed out, T-shaped (fig. 1 *a*, *b*). In the British Museum Collection there are only three specimens of *Trigonoplax*, a female from Singapore determined by Lanchester (1900, P. Z. S. p. 761), a male from Inland Sea, Japan (reg. no. 1907.4.27.5), and an unregistered male from the Gulf of Martaban. These specimens have all been referred to *Elamena* (*Trigonoplax*) *unguiformis* de Haan. In each the rostral keel is present on the posterior half of the rostrum only, and is not very prominent (fig. 1 *d* & *e*) ; according to Kemp and Tesch it may be altogether absent.

## Genus Elamena H. Milne-Edwards, 1837.

1917. Kemp, Rec. Ind. Mus. Calcutta, xiii, pt. v, pp. 270–279.
1918. Tesch, ' Siboga ' Monograph, 39 *c*, pp. 19–26.

### *Elamena mathaei* (Desmarest). (Figs. 1 *a*, *b*, 2, 3.)

1918. Tesch, ' Siboga ' Monograph, 39 *c*, p. 21, for references and synonymy.
*Nec* 1920. Stebbing, Annals Durban Museum, ii, pt. 6, p. 269, pl. xxx.

*Material*.—Ghardaqa, Red Sea, 5 ♂♂, 5 ♀♀ (three ovigerous). Collected by Dr. R. Gurney.

*Remarks*.—There can, I think, be no doubt as to the correctness of the determination in this instance.

The carapace, in each specimen, is rather wider—between the posterior pair of angular lobules—than long, the ratio of maximum width to length varying from 1·18–1·03 : 1. The front is rather more prominent in the smaller than in the larger individuals (fig. 2 *a*), but it is not easy to decide whether it is ' shortly triangular ' or ' truncate ' (see Tesch, 1918, p. 30, division 3 of key).

There is a distinct lobule on the pterygostomian region opposite the ischio-meral suture of the external maxilliped and a smaller lobule at the antero-external angle of the buccal cavity. The orbit is too shallow to contain the eyes and there is little, if any, trace of a postocular tooth.

The cheliped of the male is approximately twice the length of the carapace ; the chela is greatly inflated and that of the

largest specimen is represented in fig. 2 *c*. The fingers are nearly as long as the dorsal border of the palm ; even in the smaller males the depth of the palm is rather more than 2/3 of the length of the dorsal border. The dactylus of the third walking leg is represented in fig. 3 *b*.

The male abdomen consists of five pieces as represented in fig. 2 *c*, but the two distal sutures are so faint that they can only be seen with difficulty. The first pair of pleopods are very characteristic, and are more twisted and more expanded near the apex than in the other species examined.

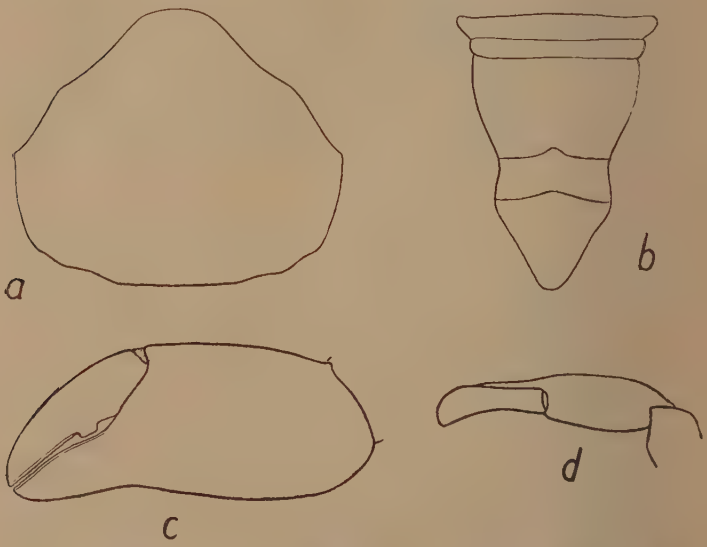


FIG. 2.—*Elamena mathaei* (Desmarest). *a*, outline of carapace of ♀, × approx. 6 ; *b*, abdomen of largest ♂ ; *c*, chela of largest ♂, × 9 ; *d*, chela of ♀, × 9.

There is a subterminal group of ten to twelve long curved setae, each of which appears to be plumose distally (fig. 3 *a* & *c*).

The cheliped of the female is shorter than that of the male—not more than 5/4 of the carapace length—and much more slender, with broadly spatulate fingers which are almost or quite in contact throughout their entire length (fig. 2 *d*).

*Size.*—All the specimens are of small size—the largest, an ovigerous female, is just under 6 mm., while the smallest ovigerous female is 3·7 mm. long.

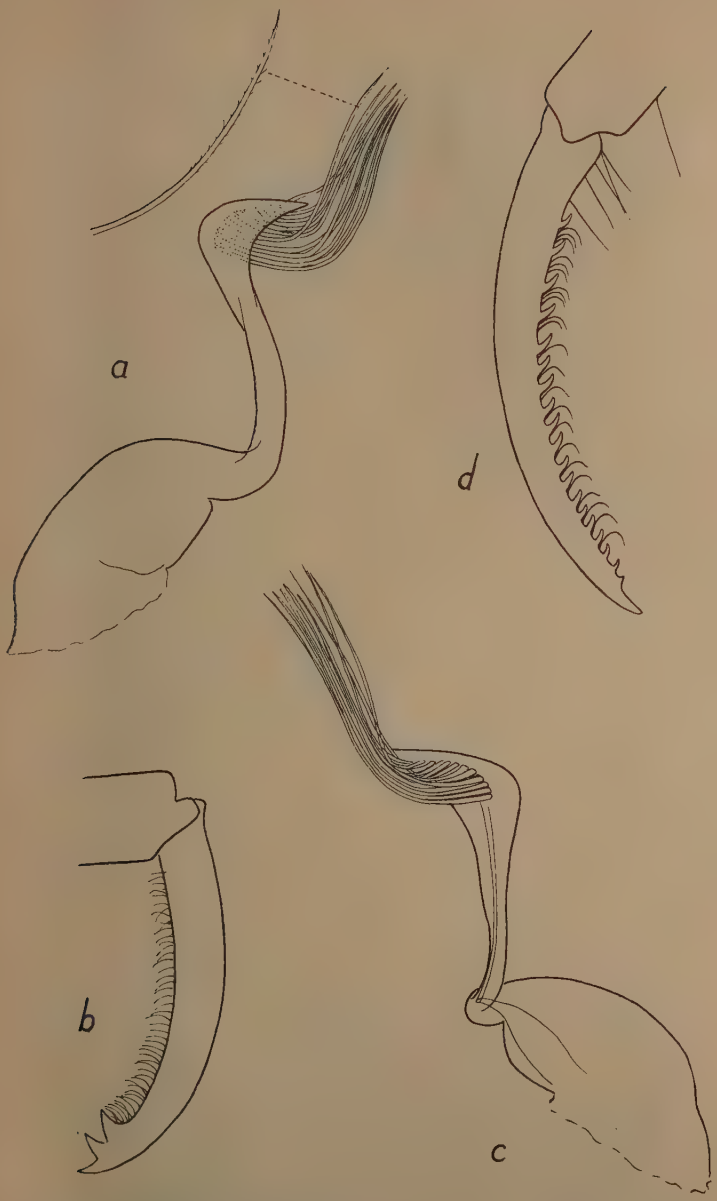


FIG. 3.—*Elamena mathaei* (Desmarest). *a* & *c*, first pleopod of male from two different aspects (*c* is the sternal or convex side), ×50. *b*, dactylus of third walking leg of ♂, ×20. *Halicarcinus whitei* (Miers), ♂ (Reg. no. 19.57). *d*, dactylus of walking leg, ×15.



*f*

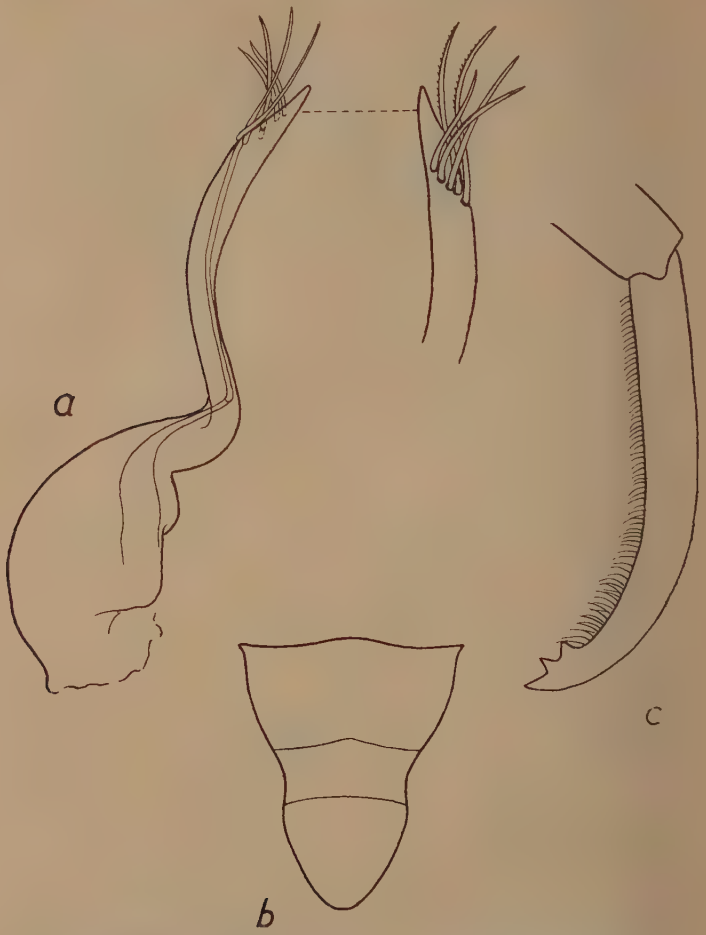


FIG. 4.—*Elamena sindensis* Alcock, ♂. *a*, first pleopod, ×50; *b*, distal portion of abdomen, the two proximal segments omitted. ×22; *c*, dactylus of third walking leg, ×22.

## *Elamena sindensis* Alcock. (Fig. 4.)

*Elamena truncata* Laurie, 1906, Rept. Pearl Oyster Fisheries, Ceylon, v, p. 248. 3 ♀♀.

*Elamena sindensis* Kemp, 1917, Rec. Ind. Mus. Calcutta, xiii, pt. 5, p. 274.

*Elamena sindensis* Tesch, 1918, 'Siboga' Monograph, 39 *c*, p. 24 (earlier references).

*Material.*—3 ♂♂, 13 ♀♀ (eight ovigerous) from Karachi, in the British Museum Collection (register numbers 82·3 and 83·5) ; 3 ♀♀ from Ceylon.

*Remarks.*—This species differs from all the other species of *Elamena*, s.s., dealt with in this paper in two respects: (1) the front is narrower and more advanced (see Alcock, 1902, Illustrations Zoology ' Investigator ', pl. lxiv, fig. 3) ; (2) thus the length of the carapace usually exceeds the maximum width. In two specimens the carapace width was exactly equal to the length ; the ratio varies from 0·91–1 : 1.

The lobule on the pterygostomian region midway between the base of the cheliped and the anterior angle of the buccal cavity is even more prominent than in *E. mathaei*. The postocular tooth, if present, is very inconspicuous.

The cheliped of the male is much more robust than that of the female ; the fingers are shorter than the dorsal border of the palm (5 : 6) ; the palm itself is 2/3 as high as long, but the males are of rather small size. In the female the fingers are rather longer than the dorsal border of the palm and are narrower and more pointed than those of *E. mathaei* ; the inner margin is distinctly crenulate.

The abdomen of the male is rather similar to that of *E. mathaei*, but the apex is broader so that the lateral margins are less sinuous (fig. 4 *b*).

The first pleopod is represented in fig. 4 *a* from the sternal side ; beyond the base it is twisted in a loose S curve ; the subterminal setae, five in number, are rather short and stout, and each bears minute spinules at least on the convex side.

The dactylus of the third walking leg is represented in fig. 4 *c*.

When Dr. C. J. Shen examined the specimens in the British Museum Collection some years ago he was of the opinion that the three small females referred by Laurie (1906, p. 248) to *E. truncata* belong to *E. sindensis*, and with this I agree. In each case the carapace is rather longer than wide and the rostrum is less truncate than in *E. truncata*.

*Size.*—The specimens vary in length from 4–6·6 mm.

### *Elamena truncata* (Stimpson). (Fig. 5.)

*Trigonoplax truncata*, 1858, Stimpson, Proc. Ac. Nat. Sci. Philad. x, p. 109.
*Trigonoplax truncata*, 1907, Stimpson, Smithsonian Inst. Misc. Coll. xlix, p. 146.
*Elamena truncata*, 1917, Kemp, Rec. Ind. Mus. xiii, p. 272.
*Elamena truncata*, 1918, Tesch, ' Siboga ' Monograph, 39 *c*, p. 22, pl. 1, fig. 4, and other references, in part.
*Elamena truncata*, 1930, Chopra & Das, Rec. Ind. Mus. xxxii, p. 424.
*Elamenx truncata*, 1932, Sakai, Sci. Rep. Tokyo Bunrika Daigaku, B. 4, pp. 44, text-fig. 2.
*Elamena truncata*, 1935, Sakai, ' Crabs of Japan ', Tokyo, Sanseido Co. Ltd. p. 72, fig. 30.

Nec *Elamena truncata*, 1906, Laurie, Rept. Pearl Oyster Fisheries . . . Manaar, v, p. 428.

Nec *Elamena truncata*, 1931, Montgomery, Journ. Linn. Soc. Lond., Zool. xxxvii, p. 426, pl. 27, fig. 2.

*Material.*—Great Barrier Reef, Australia. 6 ♂♂, 5 ♀♀ (one ovigerous).

*Remarks.*—The species, *E. truncata*, has been recorded far more frequently than any other, and appears to have a very wide distribution in the Indo-Pacific Ocean (see Tesch, 1918, p. 24). It is highly probable, however, that more than one species is represented *, and it is desirable that all the extant material be re-examined and compared with the types or, failing these, with material from Japanese waters.

The specimens from the Great Barrier Reef were referred to *E. truncata* in the first instance by F. A. McNeill of the Australian Museum, Sydney. They certainly seem to agree with Sakai's figures of Japanese material, and exhibit the variations mentioned by that author. It is unfortunate that Sakai did not figure the first pleopod or the abdomen of the male.

The lobe on the pterygostomian region is much broader than in either of the preceding two species, and is followed by another lobe situated just anterior to the base of the cheliped (*cf.* fig. 10 *a*, $l^1$, $l^2$). In ventral view the postocular tooth is rather pronounced.

The male abdomen is more narrowly triangular than in either *E. mathaei* or *E. sindensis* (fig. 5 *d*). The first pleopod is bent at an angle of about 90° a short distance beyond the base, and is slightly twisted ; there are four or five subterminal setae, each bearing minute spinules on the distal half (fig. 5 *a* & *b*).

The chela of the male is much inflated, the fingers are rather shorter than the palm, hollowed and rather spatulate at the tips ; there is a blunt tooth near the base of the movable finger, and the palm is 5/6 as deep as long. The chela of the female is much more slender, the fingers are rather longer than the palm, and almost as slender as those of *E. sindensis*, but hollowed and somewhat spatulate at the tips. The dactylus of the third leg is represented in fig. 5 *c*. The carapace is always rather broader than long—the ratio of maximum width to length varies from 1·17–1·06 : 1.

*Size.*—The carapace of the largest male measures 5 mm., that of the largest female 6 mm. in width.

* The female specimen figured by Tesch on plate 1, fig. 4 *b*, may belong to *E. abrolhensis* described below. Kemp, 1917, p. 274, has referred the *E. truncata* of Lenz to *E. mathaei*.

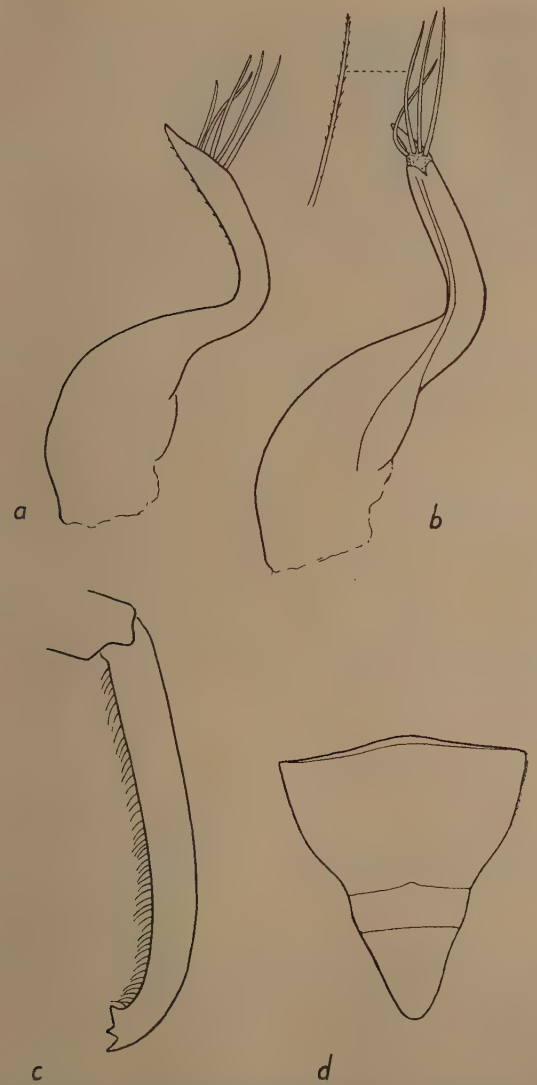


FIG. 5.—*Elamena truncata* (Stimpson), ♂. *a* & *b*, first pleopod of two different males (*b* is sternal aspect), ×50; *c*, dactylus of third walking leg, ×20; *d*, distal portion of abdomen the two proximal segments omitted.

**Elamena abrolhensis,** sp. n. (Figs. 6 *b*, *c*, 7 *a*, *c*, 10 *a*.)

*Elamena truncata* Montgomery, 1931, Journ. Linn. Soc. Lond., Zool. xxxvii, p. 426, pl. 27, fig. 2.
? *Elamena truncata*, Tesch, 1918, ' Siboga ' Monograph, 39 *c*, p. 22 in part—see pl. i, fig. 4 *b*.

*Material.*—1 ♂ (*c.l.*=5·9, *c.b.*=6·6 mm.), from Sandy Island, Abrolhos. Holotype, reg. no. 1931.7.24.37.

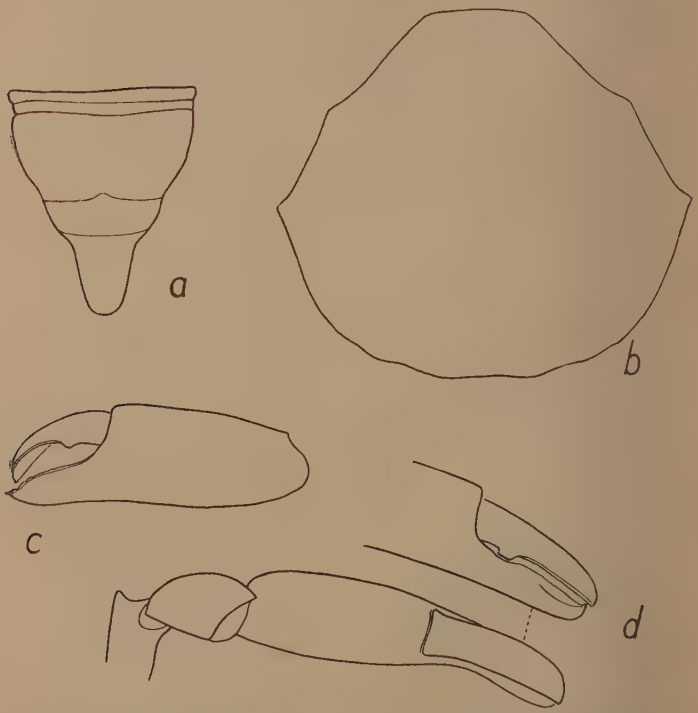


FIG. 6.—*Elamena abrolhensis*, sp. n., ♂. *b*, outline of carapace, ×9. *c*, chela, ×7. *Elamena gracilis* Borradaile, ♂ cotpye. *a*, abdomen, ×15; *d*, chela, ×12.

*Description.*—The outline of the carapace is rather similar to that of *E. mathaei*, but the angles on each lateral margin are more pronounced, and the front is broader and rather more truncate (fig. 6 *b*). The ratio of maximum width to length is 1·12 : 1. The rostral keel is not visible in dorsal

view ; the dorsal surface of the carapace is slightly convex *, and the rim of the carapace is not upturned. As in *E. truncata* there are two lobes on the pterygostomian region, that just anterior to the cheliped base being rather small (fig. 10 *a*, $l^1$ & $l^2$). In ventral and lateral views the postocular tooth is distinct.

Only the left cheliped now remains ; it is not quite twice the length of the carapace. The movable finger is approximately three-quarters of the dorsal border of the palm ; the palm itself is almost twice as long as high (fig. 6 *c*). The fingers when closed probably meet only at the tips, leaving a rather wide gap.

The abdomen differs markedly in shape from that of *E. truncata* from the Great Barrier Reef (*cf.* figs. 5 *d* & 7 *c*).

The first pleopod is also quite distinct ; the distal part is longer relatively to the base, is twisted in a loose S-shaped spiral, and there is a subterminal group of about twelve setae, each of which appears to be devoid of spinules or plumules (fig. 7 *a*).

The dactylus of the third walking leg is broader in proportion to its length than in *E. mathaei*, *E. truncata*, or *E. sindensis* (*cf.* figs. 7 *b*, 5 *c*, & 4 *c*).

*Remarks.*—The differences in the male abdomen and first pleopod as well as in the shape of the carapace necessitate the separation of this specimen from those collected at the Great Barrier Reef, and referred provisionally to *E. truncata.* It is probable that part of Tesch's material of *E. truncata* may also be referable to this species—at any rate, the female represented in pl. i, fig. 4 *b*, is very similar to the Albrohos specimen (*cf.* with fig. 6 *b*).

*Elamena gracilis* Borradaile. (Fig. 6 *a*, *d*, 7 *d*, 1 *c*.)

1903. Borradaile, ' Fauna . . . . Maldive and Laccadive Archipelagoes ', ii, pt. 2, p. 684.

*Material.*—The male and ovigerous female cotypes from Hulule, Malé Atoll, sent on loan by Mr. J. H. Lochhead of the Cambridge University Museum.

*Description.*—Both these cotypes are considerably more narrowly triangular than that figured by Borradaile (p. 684, fig. 122), and the characteristic angle at the junction of antero- and postero-lateral borders is situated further back. The ratio of maximum width to length of the carapace in both specimens is 1·14 : 1, whereas in the figured female it is about 1·22 : 1.

* The sunken condition of the dorsal surface, frequently observed in the genus *Elamena*, may be an artefact ; most of the specimens of *E. truncata*, for example, are slightly convex.

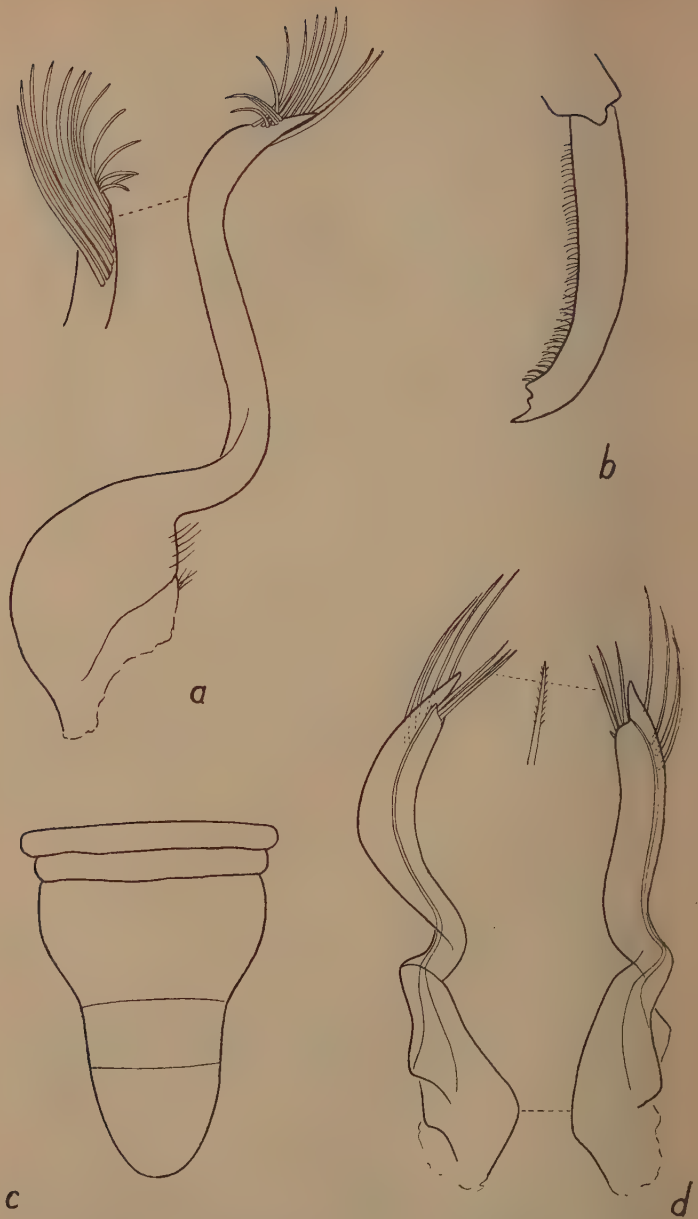


FIG. 7.—*Elamena abrolhensis*, sp. n. *a*. First pleopod, ×60; *b*, dactylus of third walking leg, ×12; *c*, abdomen, ×8. *Elamena gracilis* Borradaile, ♂ cotype. *d*, first pleopod in two different aspects, ×50.

The ventral rostral keel is deep, and extends to the anterior margin of the rostrum, so that in the male it is just visible in dorsal aspect (fig. 1 *c*).

The postocular lobule is small, but distinct. There is no lobe on the pterygostomian region apart from that at the antero-lateral angle of the buccal cavity.

The chelipeds of the male (*c.b.* just under 4 mm.) are very similar to those of the female (*c.b.* just under 6 mm.), but they are slightly unequal; the fingers are shorter than, not equal to *, the dorsal border of the palm, and there is a broad tooth near the proximal end of the movable one (fig. 6 *d*). They are considerably more robust than the walking legs.

The abdomen of the male differs in shape from that of all the previously described species (fig. 6 *a*).

The first pleopod of the male is spirally twisted immediately beyond the expanded base, and bears two groups of subterminal setae, three short and four longer and more slender ones, as represented in fig. 7 *d*. The short straight setae have each a few spinules on the distal half; the longer setae appear to have neither spinules nor pinnules.

The walking legs are all detached from the specimens; the dactylus of one is unusual in that it has three, instead of the usual two, teeth near the claw.

*Remarks.*—Kemp (1917, Rec. Ind. Mus. xiii, pt. v, p. 279), who had not seen the specimens, was not sure whether this species should be referred to *Elamena*, s.s., or to *Trigonoplax*. In shape of carapace the two cotypes from Hulule are rather similar to *Elamena* (*Trigonoplax*) *unguiformis* de Haan, as figured by Kemp (1917, p. 278, fig. 28). Although the male cotype is of small size the larger chela is more robust than that of the female, and in older specimens it is probable that the difference may be more striking. The vertical keel on the lower surface of the rostrum is so conspicuously developed that I have no hesitation in referring the species to *Elamena*, s.s. (fig. 1 *c*).

*Halicarcinus whitei* (Miers). (Figs. 3 *d*, 8, 9, 10 *b*.)

*Halicarcinus depressus* White, 1846, Ann. Mag. Nat. Hist. (1) v, p. 187 (nec *Hymenosoma depressum* Jacq. & Lucas).

*Halicarcinus depressus* White, 1847, List Crust. Brit. Mus. Coll. p. 34.

*Elamene whitei* Miers, 1876, Ann. Mag. Nat. Hist. (4) v, p. 221.

*Elamene whitei* Miers, 1876, Cat. Crust. New Zealand, p. 52, pl. i, fig. 4.

*Elamena whitei* Tesch, 1918, 'Siboga' Monograph, 39 *c*, p. 20 (in key), p. 24.

Nec *Elamena whitei* Filhol, 1885, Miss. le Campbell . . . Recueil de Mémoires Passage de Vénus, iii, pt. 2, p. 403, pl. 47, figs. 2–3.

* Or, as in Borradaile's figure, slightly longer than the palm.

*Material.*—The type-specimens comprising :—

*a.* 1 ♂, accompanied by a label, presumably in White's writing, '*Hymenosoma depressum* Hombr. & Jacq. pl. 5, fig. 34'. New Zealand. Reg. no. 45.30. (*c.l.*=11·3, *c.b.*=10·8 mm.).

*b.* 2 ♂♂, 1 ovigerous ♀, Bay of Islands, New Zealand. Reg. no. 19.57 (larger ♂ *c.l.*=14, *c.b.*=12·5 mm., ♀ 9·4 and 8·7 mm.).

These specimens were dry, but have now been relaxed and placed in the spirit collection.

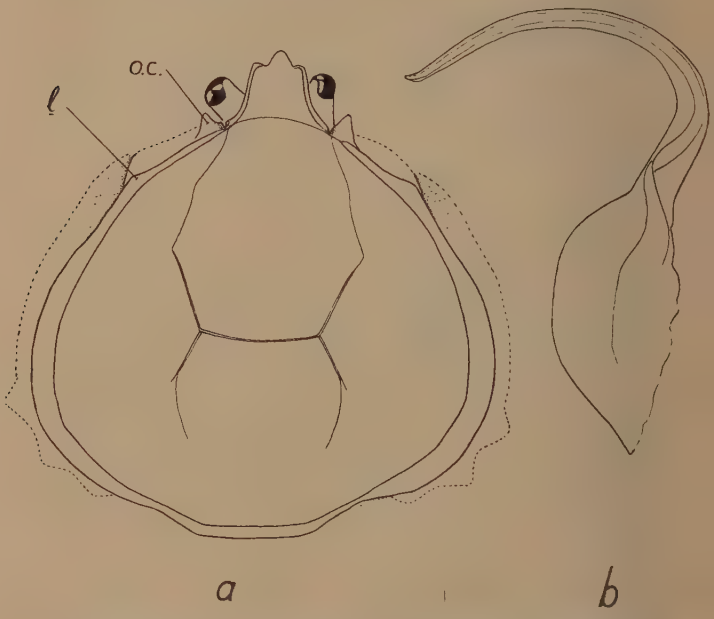


FIG. 8.—*Halicarcinus whitei* (Miers). *a*, carapace of smallest male (Reg. no. 45.30) in dorsal aspect (× approx. 6) ; *b*, first pleopod of male (Reg. no. 19.57), × 20 ; *o.c.*, postocular lobe.

*Description.*—The dorsal surface of the subcircular carapace is flat, but the cardiac and gastric regions, which are bounded by fine lines or sutures, are slightly raised. A clearly defined line or suture marks the inner edge of the slightly raised rim that constitutes the lateral and posterior margins of the carapace, and is continued across the base of the rostrum.

Teeth or spines are absent from the lateral margins, but there is an obtuse lobule (*l*) some distance behind the prominent postocular lobe (*o.c.*, fig. 8 *a*). The prominent rostrum is directed downwards at a slight angle to the dorsal surface, and the median lobe is situated at a lower level than the lateral ones. The sides of the carapace project beyond the rim of the dorsal surface, and are represented in fig. 8 *a* by broken lines.

The epistome is rather short, and there is a conical spine or process external to, and rather in advance of, the antennal gland, which may be termed the antennal spine (*a.s.*, fig. 9 *a*). The postocular lobe is also conspicuous in ventral aspect (*o.c.*). A long low rostral keel extends backwards from the median lobe to touch the anterior end of the narrow inter-antennular septum (*k* & *s*, fig. 9 *a*).

The chelipeds of the male are equal, and much more robust than the walking legs. The distal portion of the right cheliped of the smallest male (45·30) is represented in fig. 9 *b* ; the chela is considerably shorter than the maximum width of the carapace (3 : 4 approx.), and the dactylus bears a prominent tooth concealed by a felt of fine hairs, which is most pronounced on the inner surface. In the largest specimen the chelipeds are twice as long as, and the chela is equal to, the maximum width of the carapace ; with the exception of the distal half of the fingers, the chela is clothed with a fine brownish felt. The fingers are slightly longer than the dorsal margin of the palm, and are sharply pointed, but, as they are bent inwards somewhat, the tips may appear rather truncated (fig. 9 *c*).

The right cheliped of the single female specimen is missing ; the left one is shorter than, and almost as slender as, the walking legs, and is just a trifle longer than the carapace. The sharp-pointed fingers are relatively longer than in the male, and there is no conspicuous tooth on the dactylus *.

The walking legs are very slender, the first two pairs are subequal and are scarcely twice the length of the carapace. The dactylus is rather longer than the propodus, and the ventral (posterior) margin is armed with a series of 14–18 recurved teeth as represented in fig. 3 *d*. The chelipeds and walking legs and sides of the carapace are clothed with longish hairs, which are replaced on the chelae of the larger males by the much shorter dense felt mentioned above.

The distal portion of the male abdomen is represented in fig. 9 *b* ; the first pleopod is very curved, as shown in fig. 8 *b*.

*Remarks.*—This species falls into section 4 of Tesch's key to the genera of the family Hymenosomidae (Tesch, 1918,

* Ratio of length of dactylus to upper border of palm 1·25 : 1.

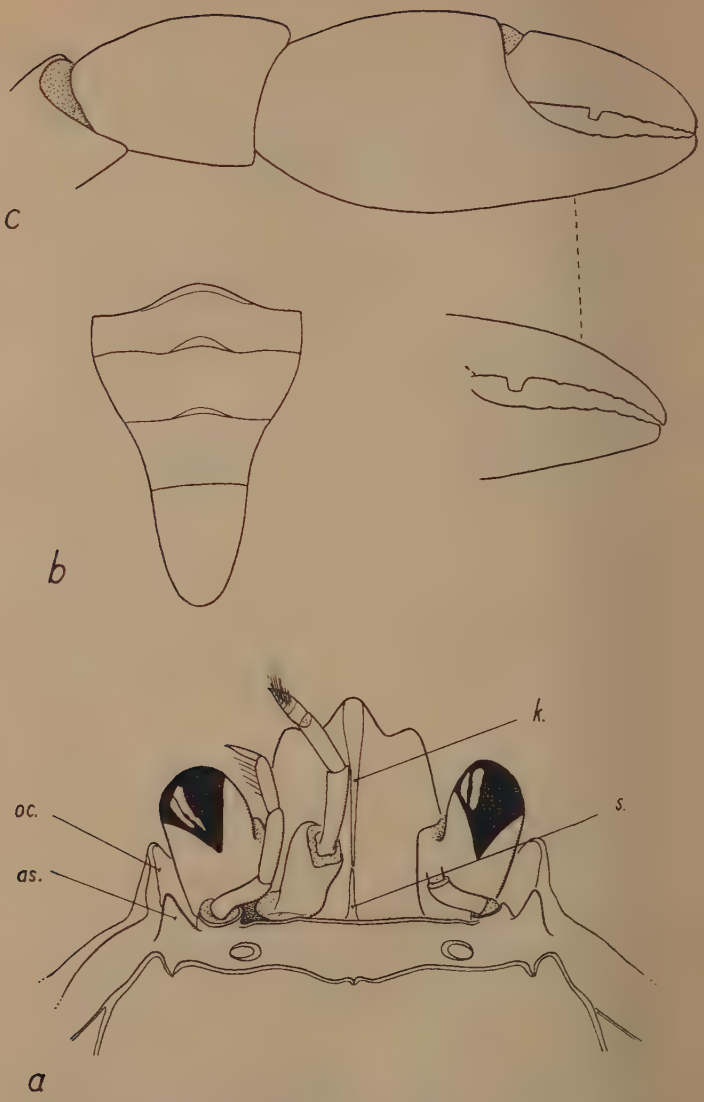


FIG. 9.—*Halicarcinus whitei* (Miers). *a*, anterior portion of carapace, in ventral aspect (Reg. no. 19.57), × approx. 14; *b*, distal portion of abdomen of male (Reg. no. 45.30); *c*, distal portion of cheliped of male (Reg.no. 45. 30), × approx. 8. *k.*, *s.*, as in fig. 1; *oc.*, postocular lobe; *as.*, antennal spine.

p. 4), since it has a line or suture subparallel to the lateral and posterior margins of the carapace, and continued across the base of the rostrum. The long walking legs place it in

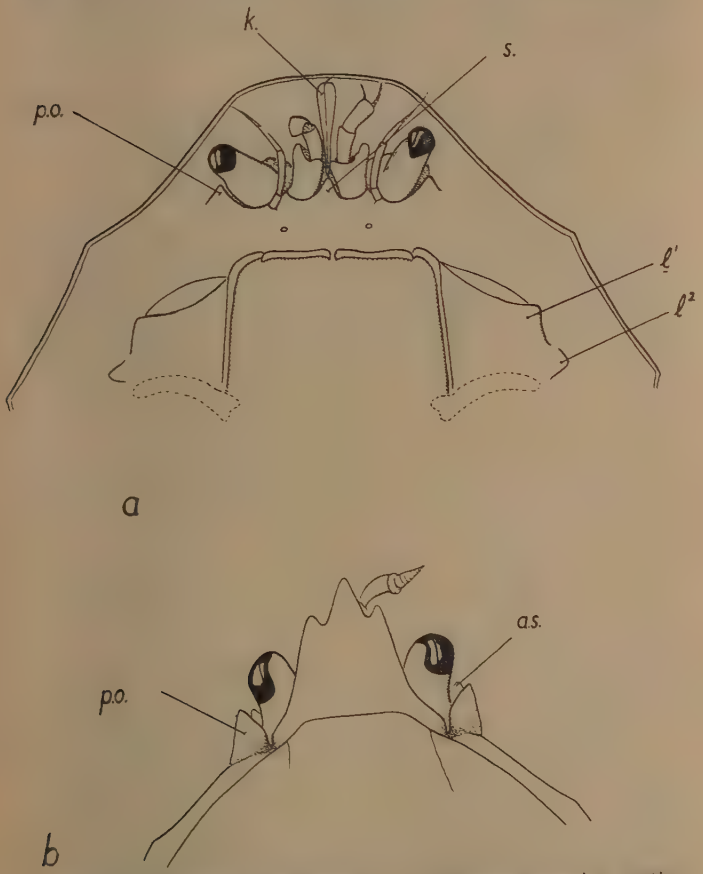


Fig. 10.—*a*, *Elamena abrolhensis*, sp. n., holotype, anterior portion of carapace in ventral aspect, × 13. *Halicarcinus whitei* (Miers), ♂ (Reg. no. 19.57). *b*, anterior portion of carapace, × 8.

*k* & *s* as in fig. 1; *p.o.*, postocular lobe; $l^1$ & $l^2$, lobes on pterygostomian region.

section 6, which contains the two genera *Hymenicus* Dana (=*Halicarcinus* White) and *Rhynchoplax* Stimpson, and the form of the rostrum would appear to place it in the former.

The external maxillipeds do not cover the entire buccal cavern, but they are broader than those of the genus *Rhynchoplax*. The male abdomen appears to consist of six pieces, but I think there are seven, and that the second segment is of unusually small size (see Kemp, 1917, p. 250, key to genera). I therefore refer the species to the genus *Halicarcinus* White.

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## THE EFFECT OF RHIZOCTONIA SOLANI KÜHN ON THE GERMINATION OF LETTUCE SEED AT SOMEWHAT HIGH TEMPERATURES.

By A. F. El-Helaly, B.Sc., Ph.D., F.L.S.

In the course of an investigation of the Damping-Off Disease of Lettuce the surprising result was obtained that the presence of *Rhizoctonia Solani* in sterilized (autoclaved) soil increased the percentage of germination of lettuce seed at a somewhat high temperature (25–30° C.). The effect was looked upon at first as due to experimental error, but in various tests it was so pronounced and appeared with such regularity that it became evident that it could not be explained away on that basis. The following is an account of experiments directed towards the elucidation of this point.

The work was carried out during 1932 and 1933 in the laboratory of the Imperial College of Science and Technology at South Kensington. The fungi used were selected from stock cultures kept in the Department or from isolations made from time to time by the writer. Cultures for experiment were maintained in tubes of 2 per cent. malt extract agar, and, unless it is otherwise stated, the lettuce seed used was of the Trocadero variety.

Soils and soil mixtures were obtained from the Chelsea Physic Garden. The general mode of inoculating soil was as follows :—

A sample of soil was autoclaved at 20 lb. pressure for half an hour, then divided into two roughly equal portions. One of these was inoculated by mixing it with a culture of the fungus on malt agar at approximately the rate of 1 tube of culture to 1 kilogram of soil. The mixture was then kept in a 20° C. incubator for 7–10 days or at laboratory temperature for a longer period. It was kept fairly moist and stirred at intervals. The other half of the soil was mixed with an equivalent amount of malt agar only, but otherwise was treated similarly.

At the end of this incubation period the soils were potted and sown with definite numbers of lettuce seed. Either porous pots or glass jars were used, the latter for preference as they maintained soil moisture more easily. The seeds

were generally sown on the surface of the soil. The pots were set in saucers containing a little water, which was renewed from time to time. Pots or jars were covered with moist filter-paper or glass lids.

The experimental containers were then incubated at a temperature which varied in the different experiments from 25 to 30° C.

In some experiments the soil was replaced by agar media in plates, with or without a fungus.

### Experimental results.

a. *General.*—The type of result shown may be illustrated by the record of a particular experiment. A sample of ordinary garden soil was treated in the manner already described. Three pots of soil which had been inoculated with *R. Solani* were each sown with 100 Trocadero lettuce seed and incubated at 25–26° C. Controls were set up in three other pots. The sowings were made on 1 April, 1932, and successive readings of the number of plants germinated made as shown in Table I.

Table I.

Number of seeds which germinated out of 100.

| Date. | Control pots. | Inoculated pots. |
|---|---|---|
| 5. 4. 32 | 3, 5, 6 | 14, 14, 21 |
| 8. 4. 32 | 7, 11, 9 | 22, 21, 33 |
| 14. 4. 32 | 22, 24, 29 | 31, 34, 65 |
| 19. 4. 32 | 23, 25, 35 | 42, 41, 71 |
| Average... | 28 per cent. | 51 per cent. |

Thus the percentage of germination in the control pots was only about half of that in the inoculated pots. It may be added that the percentage of germination of commercial lettuce seed under optimal conditions of temperature (15–20° C.) usually runs about 80–90 per cent.

Table II contains in summary form the results of a large number of experiments carried out in the manner indicated, the fungus in all cases being *R. Solani*. The experiments in the first portion of the table were carried out with soil, those in the latter portion with plates of 2 per cent. malt agar medium.

In thirty-three experiments the percentage of germination in presence of the fungus exceed those in the controls in thirty-two cases; in only one experiment was an adverse result recorded. In the different experiments there was considerable variation in the distinctness of the results. This is not surprising when one remembers that the range of temperature

Table II.

| Temperature. | No. of pots or plates used. | Duration of experiment. | Per cent. germination. | |
|---|---|---|---|---|
| | | | Inoc. | Non-inoc. |
| 30° C. | 1 *pot* | 16 days | 26 | 16 |
| 30° C. | 1 „ | 14 „ | 28 | 4 |
| 25° C. | 1 „ | 16 „ | 58 | 22 |
| 25° C. | 1 „ | 14 „ | 72 | 34 |
| 26° C. | 1 „ | 18 „ | 51 | 23 |
| 26° C. | 1 „ | 22 „ | 49 | 26 |
| 30° C. | 1 „ | 12 „ | 14 | 2 |
| 30° C. | 7 „ | 20 „ | 12 | 7 |
| 30–27° C. | 4 „ | 18 „ | 18 | 8 |
| 26·5° C. | 3 „ | 18 „ | 51 | 28 |
| 28–27° C. | 5 „ | 30 „ | 25 | 10 |
| 27–30° C. | 3 „ | 28 „ | 9 | 5 |
| 26° C. | 1 „ | 16 „ | 44 | 26 |
| 26° C. | 1 „ | 15 „ | 52 | 20 |
| 25° C. | 1 „ | 18 „ | 62 | 20 |
| 27° C. | 1 „ | 13 „ | 24 | 6 |
| 26° C. | 1 „ | 17 „ | 26 | 18 |
| 26° C. | 1 „ | 23 „ | 48 | 25 |
| 26° C. | 1 „ | 23 „ | 66 | 42 |
| 26° C. | 1 „ | 21 „ | 50 | 26 |
| 26° C. | 1 „ | 20 „ | 52 | 25 |
| 26° C. | 1 „ | 16 „ | 60 | 58 |
| 26° C. | 2 „ | 16 „ | 64 | 53 |
| 20° C. | 1 *plate* | 10 „ | 69 | 35 |
| 30° C. | 1 „ | 10 „ | 5 | 1 |
| 25° C. | 1 „ | 8 „ | 76 | 35 |
| 30° C. | 1 „ | 8 „ | 1 | 0 |
| 25° C. | 2 „ | 9 „ | 32 | 20 |
| 25° C. | 2 „ | 9 „ | 62 | 48 |
| 25° C. | 3 „ | 10 „ | 52 | 14 |
| 25° C. | 5 „ | 7 „ | 52 | 21 |
| 25° C. | 2 „ | 12 „ | 53 | 69 |
| 27° C. | 3 „ | 8 „ | 27 | 0 |

within which the effect is shown is rather narrow. Below 25° C. approximately theoretical (80–90 per cent.) germination takes place, and above 30° C. no germination. The range within which there is a clear difference is narrower still, and it appears to vary somewhat with the details of preparation, being sometimes nearer 25° C. and at other times nearer 30° C. In the experiments quoted in Table II this optimal temperature zone was not always achieved. In general one may say that the clearest results are obtained when temperature is so adjusted that the percentage of germination in presence of the fungus runs between 20 and 60 per cent.

b. *Temperature.*—The effect of temperature, to which reference has already been made, is shown in Tables III and IV, each of which gives the percentage of germination in two

experiments. Tables III and IV refer to experiments with pots and plates respectively. In the former two fungi were used, viz., *R. Solani* from lettuce and tomato. These are indicated respectively by the symbols R.S.L. and R.S.T.

TABLE III.

| Temperature. | Experiment 1. Per cent. germination. | | | Experiment 2. Per cent. germination. | | |
|---|---|---|---|---|---|---|
| | R.S.L. | R.S.T. | Cont. | R.S.L. | R.S.T. | Cont. |
| 35° C. | 0 | 0 | 0 | 0 | 0 | 0 |
| 30° C. | 26 | 28 | 16 | 28 | 38 | 8 |
| 25° C. | 58 | 50 | 22 | 72 | 70 | 34 |
| 20° C. | 86 | 84 | 68 | 97 | 89 | 89 |
| 15° C. | 96 | 86 | 88 | 88 | 82 | 92 |
| 10° C. | 92 | 92 | 84 | 96 | 98 | 87 |
| 1° C. | 0 | 0 | 0 | 0 | 0 | 0 |

TABLE IV.

| Temperature. | Experiment 1. Per cent. germination. | | Experiment 2. Per cent. germination. | |
|---|---|---|---|---|
| | R.S.L. | Control. | R.S.L. | Control. |
| 30° C. | 1 | 0 | 5 | 1 |
| 25° C. | 76 | 35 | 69 | 35 |
| 20° C. | 81 | 76 | 59 | 78 |

In both tables it is seen that at temperatures up to and including 20° C. the effect is indistinct and uncertain, and that 30° C. may be too high a temperature for purposes of the experiment, as was somewhat the case in Table IV.

c. *Nature of substratum.*—1. *Soil.* A comparison was made with the following soil types :—

1. Garden soil from Chelsea Physic Garden.
2. Loam (top spit of grassland soil).
3. Pure sand.
4. 50 per cent. sand + 50 per cent. garden soil.
5. Clay.
6. Decayed leaf soil.
7. Peaty soil.
8. Garden soil + 5 per cent. lime added before or after sterilization.

The soils were sterilized either by heat or by formalin. In the latter case the soil was saturated with a 1 per cent. solution of formaldehyde, kept under cover for 24 hours and then left exposed in a thin layer for 14 days before seed sowing.

The method of experiment was as already described. Table V gives the results obtained in this connection, the fungus being, as usual, the strain of *R. Solani* from lettuce.

TABLE V.

| Soil. | Heat sterilization. Av. of 4 pots, 17 days, 26° C. Per cent. germination. | | Heat sterilization. Av. of 2 jars, 15 days, 26° C. Per cent. germination. | | Formalin sterilization. 1 jar, 9 days, 27° C. Per cent. germination. | |
|---|---|---|---|---|---|---|
| | Inoc. | Cont. | Inoc. | Cont. | Inoc. | Cont. |
| Garden soil ..... | 46 | 18 | 55 | 23 | 65 | 27 |
| Loam ..... | 37 | 12 | — | — | — | — |
| 100 per cent. sand ... | 46 | 45 | 80 | 79 | — | — |
| 50 per cent. sand .... | 29 | 19 | — | — | — | — |
| Clay ..... | 24 | 17 | — | — | — | — |
| Leafy soil ..... | 41 | 6 | 41 | 20 | 36 | 14 |
| Peaty soil..... | — | — | 45 | 28 | 70 | 35 |
| 5 per cent. lime [1] .... | 39 | 10 | 39 | 35 | — | — |
| 5 per cent. lime [2] .... | — | — | 26 | 32 | — | — |

[1] Lime added after sterilization.
[2] „ „ before „

Leaving aside for the moment the last two soil preparations, we see that the favouring effect of the fungus is shown on all soil types except pure sand. On this fairly good germination is obtained whether the fungus is present or not, and in fact germination on sand is better than on any other medium. It is interesting also that the same effect of the fungus is shown in soils which have been sterilized with formalin.

The results obtained with limed soils were so uncertain that this point was further examined, with the results set forth in Table VI.

TABLE VI.

| Temperature. | No. of pots or jars used. | Duration of experiment. | Garden soil. Without lime. Per cent. germination. | | Garden soil. With 5 per cent. lime. Per cent. germination. | |
|---|---|---|---|---|---|---|
| | | | Inoc. | Cont. | Inoc. | Cont. |
| 26° C. | 2 pots | 19 days | 50 | 25 | 36 | 37 |
| 26·5° C. | 1 jar | 21 „ | 37 | 24 | 18 | 17 |
| 25° C. | 2 „ | 20 „ | 61 | 26 | 25 | 26 |
| 26° C. | 1 pot | 16 „ | 50 | 26 | 34 | 32 |
| 26° C. | 8 „ | 15 „ | — | — | 22 | 30 |

These data indicate that the favourable effect arising from the presence of *R. Solani* is not shown in soil with a high lime content.

2. *Artificial medium.* Petri dish cultures of *R. Solani* were set up on the following media :—

2 per cent. plain agar.
2 „ „ malt extract agar.
1 „ „ „ „ „
Brown's α solution agar.
Richards' „ „
1, 2, 4 per cent. glucose agar.
1, 2, 4 per cent. cane-sugar agar.

After 10 days' incubation at laboratory temperature 100 lettuce seeds were sown on each plate and incubated at 27° C. ; a parallel series of plates were also run at laboratory temperature. Similar uninoculated plates served as controls. The percentages of germination shown after 8 days are given in Table VII.

TABLE VII.

| Medium. | Laboratory temp. Per cent. of germination. | | 27° C. Per cent. of germination. | |
|---|---|---|---|---|
| | Inoc. | Cont. | Inoc. | Cont. |
| 2 per cent. plain agar.... | 66 | 91 | 74 | 76 |
| 1 per cent. malt extract . | 66 | 76 | 60 | 13 |
| 2 per cent. „ „ . | 73 | 81 | 27 | 0 |
| Brown's α ..... | — | — | 53 | 57 |
| Richards' ..... | — | — | 0 | 0 |
| 1 per cent. glucose ..... | 83 | 91 | 75 | 50 |
| 2 per cent. „ ..... | 79 | 82 | 59 | 11 |
| 4 per cent. „ ..... | 83 | 78 | 7 | 1 |
| 1 per cent cane-sugar.... | 85 | 92 | 61 | 66 |
| 2 per cent. „ „ .... | 86 | 88 | 21 | 22 |
| 4 per cent. „ „ .... | 88 | 85 | 12 | 1 |

The results indicated may be summarized as follows :

1. All the media tested were suitable for germination of lettuce seed at laboratory temperature, and the presence of the fungus had no material effect on the early stages of germination.

2. At the higher temperature there was considerable difference shown as from one medium to the other, and the rule appears to be that the richer the medium the less suitable it is for germination.

3. With media on which fairly good germination occurs at 27° C. the effect of the fungus is not shown. This applies to plain agar, Brown's solution agar, 1 per cent. glucose and 1 per cent. cane-sugar agars.

The behaviour of weak media, in particular of plain agar, is very reminiscent of the behaviour of sand described in connection with Table VI. It is suggested that richness of the substratum introduces a factor which is unfavourable to lettuce germination, and that the presence of *R. Solani* to some extent neutralizes this factor.

The effect of each constituent of a synthetic medium was tested in an experiment in which various modifications of a dilute Richards' solution were used. Comparisons were made between the complete medium of 1/10th strength and the same lacking each constituent in turn. Plates of these media were inoculated with *R. Solani* from lettuce and incubated at laboratory temperature for 10 days. They were then sown with 100 lettuce seeds per plate, uninoculated plates serving as controls. The results obtained after a further ten days' incubation at 28° C. are given in Table VIII. The figures are the average of a quadruplicate series.

TABLE VIII.

| Medium. | | pH. | Per cent. germination. |
|---|---|---|---|
| R.S./10 complete | Inoc. | 4·4 | 23 |
| | Cont. | 5·8 | 29 |
| „ lacking sugar | Inoc. | 5·8 | 39 |
| | Cont. | 5·8 | 16 |
| „ „ nitrate | Inoc. | 5·6 | 20 |
| | Cont. | 5·6 | 8 |
| „ „ potassium | Inoc. | 5·8 | 18 |
| | Cont. | 5·8 | 10 |
| „ „ phosphate | Inoc. | 6·5 | 17 |
| | Cont. | 6·5 | 11 |
| „ „ magnesium sulphate | Inoc. | 4·4 | 48 |
| | Cont. | 5·8 | 13 |

While the complete medium gives no difference as between the inoculated and control plates, all the others show distinctly greater germination in the former. This is particularly marked in the media lacking sugar, nitrate and magnesium sulphate.

3. *Acidity.* The pH values recorded in Table VIII indicate that changes in the acidity of the medium are not obviously connected with the stimulation of germination. A further series of data bearing on this point is included in Table IX.

In Tables VIII and IX it is seen that the stimulatory effect is shown on media the pH of which ranges from 4·4 to 8·3. In some cases there is a distinct change in the pH of the substratum as the result of fungal growth, in others not. The stimulatory effect on germination is independent of this change.

d. *Different lettuce material.*—A comparison of a number of lettuce varieties is shown in Table X, the temperature of germination being 26° C.

The results appear to be most distinct with the Trocadero variety. As Table X contains all the data available it is impossible to generalize. One would suggest that a somewhat higher temperature should be tested for such varieties as Lobjoit's Green Cos and London Superb White. It is,

TABLE IX.

| Medium. | | pH. | Per cent. germination. |
|---|---|---|---|
| Garden soil | Inoc. | 8·3 | 50 |
| | Cont. | 8·3 | 26 |
| 1 per cent. malt agar | Inoc. | 5·0 | 85 |
| | Cont. | 5·6 | 68 |
| 2 per cent. „ „ | Inoc. | 6·0 | 52 |
| | Cont. | 6·0 | 21 |

TABLE X.

| Varieties. | Garden soil, 20 days. Per cent. germination. | | Leafy soil, 22 days. Per cent. germination. | |
|---|---|---|---|---|
| | Inoc. | Non-Inoc. | Inoc. | Non-Inoc. |
| *Cos Varieties*: | | | | |
| Lobjoit's Green Cos | 81 | 67 | 81 | 76 |
| Bath Black-seeded | 14 | 1 | 16 | 15 |
| Hardy Winter White | 10 | 7 | 17 | 19 |
| London Superb White | 61 | 16 | 79 | 78 |
| *Cabbage Varieties*: | | | | |
| Trocadero | 51 | 23 | 49 | 26 |
| Lee's Immense | 45 | 42 | 43 | 42 |
| Daniels' Continuity | 3 | 5 | 17 | 19 |
| All the Year Round | 35 | 40 | 61 | 50 |
| Early Market | 21 | 26 | 21 | 27 |

of course, quite possible that certain varieties may not show the effect at all. Further work is obviously necessary.

A comparison was made of seed samples of different age of the variety Trocadero, under the idea that different vigour of germination might affect the result. The experiment was carried out with three isolations of *R. Solani* from lettuce and with the strain from tomato. The data which are presented in Table XI confirm the general conclusions already put forward.

TABLE XI

| Fungus. | Autoclaved soil. Per cent. of germination after 12 days. | | | Formalized soil. Per cent. of germination after 17 days. | | | |
|---|---|---|---|---|---|---|---|
| | 1931 seeds. | 1930 seeds. | 1929 seeds. | 1931 seeds. | 1930 seeds. | 1929 seeds. | 1927 seeds. |
| Control ..... | 37 | 42 | 31 | 38 | 36 | 28 | 33 |
| RL (1) ..... | 60 | 56 | 36 | 60 | 66 | 36 | 44 |
| RL (2) ..... | 62 | 70 | 50 | 68 | 68 | 62 | 54 |
| RL (3) ..... | 54 | 62 | 44 | 84 | 66 | 68 | 59 |
| RT ..... | 58 | 70 | 56 | 48 | 84 | 46 | 46 |

e. *Effect of different fungi.*—An experiment in quadruplicate with soil inoculated with a variety of fungi has shown that whereas the usual beneficial effect was obtained with the strains of *R. Solani* from lettuce and tomato, negative results were given by the following fungi: *Pythium spinosum*, *P. De-Baryanum*, *Marssonina panattoniana*, *Phytophthora erythroseptica*, *Penicillium chrysogenum* and two unidentified spp. of *Penicillium*, *Fusarium herbarum*, *F. sambucinum*, *F. culmorum*, *F. oxysporum* and *F. vasinfectum*. Greater success has, however, been obtained in experiments with plate cultures as shown in Table XII, the figures of which are the averages obtained from three plates, and give the percentage of germination after five days' incubation at 26° C.

TABLE XII.

| Fungus. | Per cent. germination. | |
|---|---|---|
| | Experiment 1. | Experiment 2. |
| Control ..... | 32 | 41 |
| *Rhizoctonia Solani* (lettuce) ..... | 72 | 80 |
| „ „ (tomato) ..... | 80 | 74 |
| *Rhizoctonia Crocorum* ..... | 81 | 77 |
| *Pythium spinosum* ..... | 68 | 55 |
| *Phytophthora erythroseptica* ..... | 33 | 31 |
| *Penicillium corymbiferum* ..... | 17 | 4 |
| *Fusarium vasinfectum* ..... | 51 | 35 |
| *Fusarium culmorum* ..... | 41 | 36 |

Distinct stimulation is given not only by the two strains of *R. Solani*, but also by *R. Crocorum*, and to a less extent by *Pythium spinosum*. *Phytophthora erythroseptica* and the two *Fusarium* species are inert, while the *Penicillium* species is definitely harmful.

f. *Soil moisture.*—The general procedure adopted was to maintain a fairly wet soil for the germination tests. It was found, however, that, within wide limits at least, the percentage of soil moisture was of no importance. Such a result is set out in Table XIII (incubation temperature is 25° C.). The water-holding capacity of a sample of garden soil was determined by Hilgard's method ('Soils', 1906), and water added to give 100, 75, and 50 per cent. of saturation in the various jars. Evaporation from each jar was prevented by the use of screwed metal caps.

TABLE XIII.

| Soil humidity. | Experiment 1. | | Experiment 2. | |
|---|---|---|---|---|
| | Inoc. | Cont. | Inoc. | Cont. |
| 100 per cent. ..... | 43 | 6 | 31 | 16 |
| 75 „ „ ..... | 45 | 26 | 77 | 25 |
| 50 „ „ ..... | 66 | 7 | 45 | 13 |

g. *Presence of fungus.*—Up to the present no success has been obtained in attempts to replace the active fungus by extracts containing its metabolic products. The following experiments may be cited.

(1) A sample of garden soil was treated in the manner described on p. 78; portions of the inoculated and control soils were set aside for direct test. The remaining parts were treated with enough water to make a thin paste, stirred for one hour, and then filtered through a Buchner funnel. The clear liquids were either used as such or after autoclaving to moisten clean sterile sand on which lettuce seeds were then placed to germinate at 26° C. A parallel test was made of the soils themselves. The percentage germination obtained in a triplicate test after three weeks is given in Table XIV.

TABLE XIV.

| Substratum. | Per cent. germination. |
|---|---|
| Sand + water ..... | 57·5 (av. of 5 measurements). |
| „ + autoclaved control filtrate ... | 29 „ „ |
| „ + non-autoclaved control filtrate. | 38 „ „ |
| „ + autoclaved inoculated filtrate . | 32 „ „ |
| „ + non-autoclaved inoculated filtrate ..... | 24 „ „ |
| Control soil..... | 31 „ „ |
| Inoculated soil..... | 55 „ „ |

Thus while the inoculated soil gave distinct stimulation of germination, none of the extracts, whether used directly or after autoclaving, did so.

(2) A similar type of experiment to the preceding was carried out with two artificial media which were known to be suitable for showing the effect. These were 1 per cent. malt and Richards' solution of 1/10th normal strength lacking magnesium sulphate. Flasks of these each containing 25 c.c. were inoculated with *R. Solani* and incubated at laboratory temperature for twelve days. Agar plate cultures were set up for the same period. Sowings of lettuce seed were then made on the agar plates, and on uninoculated controls, and also on clean sterile sand which was moistened either with filtrate from the flask cultures or with the respective uninoculated solutions. The data obtained after twelve days' incubation at 27° C. are contained in Table XV.

TABLE XV.

| Substratum. | Per cent. germination (average of 2 determinations). | |
|---|---|---|
| | Inoc. | Cont. |
| Sand+water | — | 52 |
| „ +1 per cent. malt filtrate | 21 | 29 |
| „ +1/10 R.S. filtrate | 28 | 30 |
| 1 per cent. malt agar plate | 32 | 3 |
| 1/10 R.S. agar plate | 14 | 5 |
| Plain agar plate | 37 | 50 |

Here again, while the inoculated plate media give distinctly better germination than the uninoculated controls, no such effect appears in the sand cultures which are watered with the various filtrates.

(3) In a third type of experiment batches of three kinds of soil were treated in the routine way described on p. 78, and then portions of each sterilized a second time. Sowings of lettuce seed were then made on the various soil preparations. The results obtained after three weeks' incubation at 25·5° C. are given in Table XVI.

TABLE XVI.

| | Per cent. germination. | |
|---|---|---|
| | Inoc. | Cont. |
| Leaf soil : | | |
| (1) Sterilized once | 30 | 13 |
| (2) „ twice | 8 | 8 |
| Peaty soil : | | |
| (1) Sterilized once | 42 | 25 |
| (2) „ twice | 20 | 25 |
| Garden soil : | | |
| (1) Sterilized once | 38 | 16 |
| (2) „ twice | 13 | 16 |

The general conclusions from Tables XIV–XVI are that the stimulatory effect is not obtained in the absence of the fungus. The question therefore arises as to whether the fungus comes into any intimate relationship with the seedling at about the time of germination of the latter.

Observations on this point have so far led to no definite conclusion. When seeds are placed to germinate on the surface of plate cultures of *R. Solani*, and the latter maintained at a temperature ranging from 25–30° C., hyphae which undoubtedly belong to the fungus mentioned are almost invariably present in abundance, forming a kind of weft, on the surface of the seeds (=fruits), and they are readily demonstrable on the surface of the hypocotyls of young seedlings (three to four days after germination). So far invading hyphae have not been seen, nor have any hyphae been observed on the surface of the hypocotyl or of the primary root at the period of first emergence of the seedling. The same statements apply to seeds germinated on inoculated soil, with this difference, that the amount and percentage of surface contamination is considerably less both on seed coats and on hypocotyls of seedlings.

## Discussion of results and some further observations.

The interest of this investigation is that here we have the case of a fungus (or fungi) which at lower temperatures causes a pronounced disease of the plant (damping-off), but which at temperatures too high for disease production stimulates germination. The interest is enhanced by obvious analogies between the effects described here and the well-known behaviour of orchid and other seeds in relation to symbiotic fungi, and more particularly by the fact that the fungus (*R. Solani*) which is most active in stimulating the germination of lettuce seed is closely related to if not co-specific with the common orchid fungus. The position will now be reviewed from this standpoint.

The relation of the so-called endophyte to the seedlings of certain groups of plants (*Orchidaceae*, *Ericaceae*, etc.) is somewhat controversial. Whereas certain workers, e.g. Bernard (L'évolution dans la symbiose des Orchidées et leurs Champignons commensaux, in Ann. Sci. Nat. Bot., IX, pp. 1–96 : 1909), Ramsbottom (Orchid mycorrhiza. Reprinted from Charlesworth and Co.'s Catalogue, pp. 1–18 : 1922) and Rayner (Obligate symbiosis in *Calluna vulgaris*, in Ann. Bot., XXIX, pp. 97–133 : 1915) claim that the fungus definitely stimulates germination by invasion of the seedling, so that something like an obligate relationship exists, others, of whom the most notable is Knudson (Physiological study of the symbiotic germination of Orchid seeds, in Bot. Gaz. LXXIX.

pp. 348–80 : 1925), consider that the fungus, though it may be more or less invariably present in nature, is of secondary importance, merely rendering the substratum more favourable for germination of the seeds. This it does, in the case of orchids, by providing soluble carbohydrates for the rudimentary embryo and by setting up a favourable pH concentration in the substratum. Knudson claims that he has obtained excellent germination (and even continued growth) of seeds on certain media in the complete absence of the fungus, and conversely also that certain other fungi (e.g. a *Phytophthora* sp.) can replace the specific orchid symbiont so far as the stimulation of germination is concerned. According to Knudson the local penetration of the fungus is to be looked upon as a kind of harmless parasitism.

So far as one can judge from the papers cited the effect of the presence of a suitable fungus on the germination of orchid or heath seeds is more clear cut than is shown in the present investigation with lettuce seed. Also the effect is shown with the former at ordinary temperatures, whereas with the latter it is only found within a limited range of rather high temperatures. At ordinary temperatures (up to about 20° C.) lettuce seed shows theoretical germination (80–90 per cent.) according to sample both in inoculated and control soils, and the only difference is that in the former a high percentage of seedlings may later damp off. A further difference which may be of significance is that the germination of orchid or heath seeds is relatively slow under all conditions, requiring apparently weeks or months, whereas that of lettuce is very rapid, usually requiring only a few days. How far there is a resemblance between the phenomena described in this paper and in the works relating to germination of orchids will depend to a large extent on whether one accepts the ideas of the Bernard or the Knudson school in this connection.

The significant points regarding lettuce germination may be summarized as follows :—

(1) At rather high temperatures (25–30° C.) a certain percentage of viable seeds remains dormant. If the temperature is lowered germination of the remainder up to the theoretical amount (80–90 per cent.) takes place immediately. The treatment does not harm the seeds ; it merely inhibits germination.

The percentage of dormant seeds is less on weak than on stronger media—e.g. on sand as against garden soil, on plain agar as against agar with 2 per cent. malt etc. On such stronger media the presence of the fungus causes enhanced germination, while on weak media there is no benefit.

(2) The stimulatory effect of the presence of the fungus appears to have no relation to the setting up of a particular

pH concentration in the substratum. This differs from Knudson's findings with regard to orchid seeds, according to which an optimal pH exists in the neighbourhood of 4·6, and part of the beneficial effect of the fungus is considered to arise in this way.

(3) So far it has not been possible to replace the fungus by any metabolic products, but no actual penetration by the fungus has been demonstrated as yet.

(4) The most active fungus is *R. Solani*, but there is evidence that other fungi produce some effect while others again are ineffective or even harmful.

In discussing the nature of the beneficial effect produced by *R. Solani* we may take as a starting point that garden soil which has been autoclaved gives poor germination of lettuce seed at temperatures 25–30° C. Various factors which may produce this result will now be considered.

Autoclaving of a soil is known to affect considerably the humus content, and in fact to increase considerably the soluble organic content of the soil solution. It may be postulated that this organic material is harmful to lettuce germination under the conditions of rather high temperature, and that the fungus acts simply by removing or reducing or in some way antagonizing this harmful factor. Any other saprophytic fungus might be expected to be similarly active in reducing the soluble organic content of the autoclaved soil, but the absence of a favourable effect on germination of lettuce seed would be ascribed to the production of harmful fungal products. This hypothesis, however, is discounted by two sets of data—(1) by the similar behaviour of formalized and autoclaved soils, and (2) by the fact that, as shown in Table XIV, the extract of a soil in which *R. Solani* has grown gives poor germination.

Alternatively the low germination obtained in the sterilized uninoculated soil may be ascribed to the action of contaminants. It must be remembered that the experimental preparation involves incubation of the soil for a period of about ten days, during which time it is being permeated by the mycelium of *R. Solani*. Contamination may occur in this time, more especially as the practice is to stir up the soil at frequent intervals. The lettuce seed used was not sterilized, and thus by the time the experiment is finished there has been considerable opportunity for contamination to take place. The chances in favour of growth of contaminants would be greater in the control than in the inoculated substrata seeing that no competition would be met with from *R. Solani*. Considerable contamination (due to species of *Mucor*, *Penicillium*, bacteria, etc.) has in fact appeared from time to time, especially in experiments by the plate method. As some contaminants

(e.g. *Penicillium* sp.) are known to depress germination, might it not be that the low figures for germination in control plates are to be explained in this way ? The relatively good germination obtained on weak media (sand, plain agar, etc.), whether inoculated with *R. Solani* or not, would then be due to the feeble development of all fungi under these particular conditions.

The part played by contaminants in the phenomenon under consideration can only be finally determined by working under aseptic conditions. This in practice is difficult, and any attempt to achieve perfection in that respect would have much reduced the amount of work done. It is advisable, however, that critical experiments of the kind indicated should be carried out. The writer considers that the hypothesis of contaminants is insufficient to explain the results for the following reasons :—

(1) Observation throughout the work showed that in partially contaminated plates there was no obvious correlation between the presence of contaminant and failure of seeds to germinate. One frequently saw germinated seeds lying in the middle of a fungal or bacterial colony. As a measure of safety the writer discarded all plates which were badly contaminated. It is to be remembered in this connection that the contamination of plates only takes place at the time of seeding and that the beneficial effect of *R. Solani* is generally observable within two days, i.e. before contaminants have made any appreciable growth. The contamination of soil preparations is always much less obvious than that of plates, and it is not certain that the presence of *R. Solani* in the inoculated soil would materially diminish the growth of contaminants to which both inoculated and control soils were equally exposed.

(2) The results given in Table VIII are not easily explainable on the basis of action of contaminants. If the latter are responsible for the poor germination shown by the control plates it is difficult to understand why, for example, a favourable effect of *R. Solani* is so pronounced in the medium lacking sugar, seeing that such a medium would be calculated to reduce the growth of contaminants to a minimum.

If one rejects the above two hypotheses, and ignores the possibility of stimulation by invasion of the seedling (which has not yet been demonstrated), there remains the question of an active metabolic product produced by the fungus. From the results given in Tables XIV–XVI it would appear that the only type of product in question must be thermolabile or volatile. The carbon dioxide of respiration is suggested, and some evidence can be brought forward on this point. Incidentally it is interesting to recall that Knudson

suggests such a possibility in connection with the functioning of the orchid fungus. That the causal factor might be carbon dioxide is in agreement with the results recorded in Table VI, where it is shown that the addition of an excess of lime to soil prevents any stimulating effect on the part of the fungus.

Low concentrations of carbon dioxide in the atmosphere surrounding the soil stimulate germination of lettuce seed at somewhat high temperatures. This is shown in Table XVII. The soil preparations were made in the usual way, and immediately after seeding placed in desiccators, the atmosphere of which was adjusted to different concentrations of carbon dioxide by direct addition. Two types of control atmospheres were used, one being ordinary air, the $CO_2$ content of which would be increased somewhat as the experiment progressed as a result of respiration in the soil, the other being deprived of all $CO_2$ by the inclusion of dilute caustic potash solution in the desiccator. The germination tests were conducted at 26° C.

TABLE XVII.

| Soil texture and treatment. | Duration of experiment in days. | Per cent. of germination. | | | |
|---|---|---|---|---|---|
| | | Atmosphere lacking $CO_2$. | Normal atmosphere. | 1 per cent. $CO_2$. | 2 per cent. $CO_2$. |
| Inoculated leafy soil. | 9 | 8 | 13 | 20 | — |
| Contol ,, ,, | 9 | 4 | 7 | 11 | — |
| Inoculated ,, ,, | 10 | 12 | 52 | 28 | — |
| Control ,, ,, | 10 | 5 | 18 | 37 | — |
| Inoculated garden soil. | 8 | 30 | 51 | — | 68 |
| Control ,, ,, | 8 | 23 | 41 | — | 46 |
| Inoculated ,, ,, | 5 | 17 | — | — | 44 |
| Control ,, ,, | 5 | 13 | — | — | 25 |
| Inoculated ,, ,, | 5 | 25 | — | — | 36 |
| Control ,, ,, | 5 | 7 | — | — | 19 |
| Inoculated ,, ,, | 5 | 19 | — | — | 40 |
| Control ,, ,, | 5 | 13 | — | — | 29 |

In all cases with one exception the presence of $CO_2$ in the atmosphere increased the percentage of germination.

Further experiments showed that the optimum concentration of $CO_2$ was somewhere in the region of 2–5 per cent. and that 10 per cent. was definitely too high. This is shown in Table XVIII, which refers to experiments in which the substratum was filter-paper.

It is to be remembered that in all the experiments described in this paper conditions were such as would allow of some accumulation of carbon dioxide in the atmosphere surrounding

the seeds. The experimental pots were covered with wet filter-paper, glass jars with screw caps, and Petri dishes with lids. Though no estimate can be given of the concentrations which were thus brought into being, it does appear that carbon dioxide concentration is a plausible factor. There are, however, certain difficulties.

Thus it is seen in Table XVII that in all the comparisons of inoculated and control soil, under conditions different as regards $CO_2$ concentration, germination is better, with one exception, in presence of the fungus than in its absence. The

TABLE XVIII.

| Duration of experiment. | Temperature. | Per cent. of germination. | | | |
|---|---|---|---|---|---|
| | | Atmosphere lacking $CO_2$. | 2·5 per cent. $CO_2$. | 5 per cent. $CO_2$. | 10 per cent. $CO_2$. |
| 3 days | 26° C. | 35 | 60 | 50 | 33 |
| 5 ,, | 26° C. | 12 | 40 | 24 | 5 |
| 4 ,, | 26° C. | 29 | 60 | 68 | 43 |
| 3 ,, | 26° C. | 49 | 89 | 67 | 50 |
| 3 ,, | 26° C. | 52 | 80 | 83 | 36 |
| 3 ,, | 26° C. | 53 | 81 | 68 | 39 |
| 3 ,, | 28° C. | 12 | 36 | 35 | 30 |
| 3 ,, | 28° C. | 17 | 39 | 39 | 26 |
| 3 ,, | 28° C. | 20 | 45 | 50 | 40 |

experiment is not entirely critical in so far as the exact concentration of $CO_2$ immediately surrounding the seeds is not known in any instance, but it does seem that the effect of the fungus is one superadded to that due to carbon dioxide.

A second general objection to the carbon dioxide hypothesis would be that, if it were true, there is no obvious reason why the stimulation could not be produced by saprophytic fungi generally. At the moment it is probably premature to speculate, as the data on this point are too few, but some suggestions may be put forward.

Is it possible that under the conditions of experiment adopted in this work *R. Solani*, and to a less extent perhaps some others (*R. Crocorum*, *Pythium* sp.—*vide* Table XII), are able to grow vigorously in soil, whereas the others tested make little growth, with the result that appreciable $CO_2$ is produced by the former and a negligible amount by the latter? This point could be definitely settled by experiment. The failure of some fungi to stimulate germination in the experiments with plates could reasonably be set down to the production of deleterious substances.

A possible view of the mechanism of the factors determining germination of lettuce at somewhat high temperatures is thus as follows :—

Within the temperature range 25–30° C. a considerable proportion of lettuce seed will remain dormant, especially if the substratum contains a certain amount of nutrient. This dormancy can be partly overcome by exposure to carbon dioxide concentrations (optimum 2–5 per cent.). The same effect will be obtained by the addition of any fungus which is able to grow under the conditions to such an extent as to produce a favourable $CO_2$ concentration round the seeds and which at the same time produces no deleterious products. *R. Solani* is one such fungus, but it is possible that there may be many others. Further work on this point is obviously necessary.

*Acknowledgment.*—The writer wishes to express his deep indebtedness to Prof. W. Brown, of the Imperial College of Science and Technology, under whose supervision this work was carried out, for his unfailing interest, advice and criticism during the progress of the investigation.

*Discussion.*—

Dr. Barnes suggested that, at temperatures approaching the upper limit of its tolerance for heat, *Rhizoctonia* suffered disturbances in metabolism causing the secretion of a growth promoting substance which stimulated the germination of lettuce. This seemed probable, as there was no evidence that the fruits were penetrated by fungal hyphae.

Dr. Margaret Brett stated that while working on a hitherto unrecorded smut fungus in the anthers of *Ulex nanus* considerable difficulty was experienced in germinating the seeds of the host plant. They germinated readily, however, after being dusted with the infected stamens.

The President pointed out that in considering the effect of carbon dioxide it should not be overlooked that all fungi respire and that there is therefore no difficulty in accounting for its presence in the soil.

Referring to the different theories of the method in which mycorrhizal fungi act he thought there was not the clear-cut difference often suggested. Thus for example the orchid seed is stimulated to growth by the action of sugars. The one idea is that these are carried into the seed by the fungus, the other that they are absorbed from the substratum. As in natural conditions the sugars are formed by the action of the fungus, the essential difference between the two points of view is whether or not specific mycorrhizal fungi occur.

# THE SIGNIFICANCE OF THE UNIQUE FLORAL CONSTRUCTION CHARACTERIZING A LITTLE KNOWN MEMBER OF THE PRIMULACEAE—PELLETIERA VERNA A. ST. HIL.

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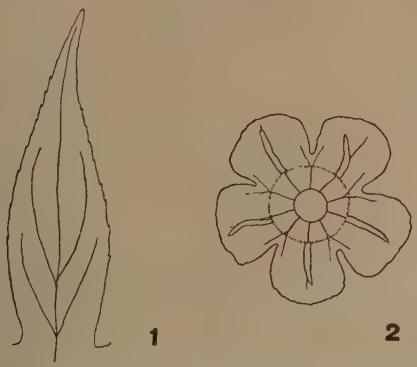
Perhaps the least known member of one of the most widely studied Families of Flowering Plants, viz. Primulaceae, is the monotypic genus *Pelletiera* *. This neglect, indicative of a lack of appreciation of the significance of the floral construction in a genus which must be reckoned among the 'key' genera in an otherwise outstandingly uniform Family, is to be explained no doubt in part, but not entirely, by the inconspicuousness of the plant, the small size of the flower and the limited areas of its distribution which lie in some of the less frequently visited regions of the world. I have written 'in part but not entirely' deliberately; for it is a fact that the gross anatomy, the highly exceptional and at the same time most instructive features of the flower have been known from the outset. The present case, indeed, affords a good example of the result of the practice of describing the appearance of a plant simply for the purposes of identification and classification without further reference to, or analysis of, these appearances when they depart from the normal ground-plan characteristic of the Family or of the particular subdivision of the Family in question.

*Pelletiera verna* is a small annual herb, abundant where it occurs, but confined to certain grassy areas situated in the province of Rio Grande do Sul in south-east Brazil; in Uraguay, particularly in the neighbourhood of Montevideo and Maldonaldo; and in a few localities in Argentina (Cordoba, Corrientes) and central Chile (Valdivia, Rancagua). Originally

* *Pelletiera verna* was collected by Commerson in the vicinity of Montevideo in 1767. It was briefly described by A. St. Hilaire in 1822 (Mém. Mus., Paris, ix, p. 365) and more fully later jointly with F. de Girard in 1839 ('Monographie des Primulacées et des Lentibulariées du Brazil méridional et de la République Argentine', in Ann. Sci. nat., Bot. ser. 2, xi, pp. 85–99 and t. 4). These authors' figures are reproduced in Miquel's account of the Primulaceae in Martius' *Flora Brasiliensis* (x, p. 259, t. 32: 1846–56) and two new figures of the whole flower appeared in Baillon's *Histoire des Plantes* (xi, p. 321, figs. 375, 376) in 1892. The more recent descriptions by F. Pax in Engler's *Pflanzenfamilien* (iv, 1, p. 113: 1897) and by F. Pax and R. Knuth in *Pflanzenreich* (pp. 318, 319: 1905) are evidently taken from these sources and add nothing new.

included as a distinct section in *Asterolinum* it has now been given rank as a separate genus. In its vegetative characters it closely resembles *Asterolinum stellatum*, but the flower exhibits marked and significant differences. This will be apparent from the descriptions of the two species appended for comparison below.

ASTEROLINUM STELLATUM Link & Hoffmgg.—K5 C5 A5+5, i.e. A5 (represented by their vascular bundles which run up the tube of the corolla and forking below the level of separation of the individual petals give rise to a separate marginal system in the petal lobe on each side), +5, epipetalous,



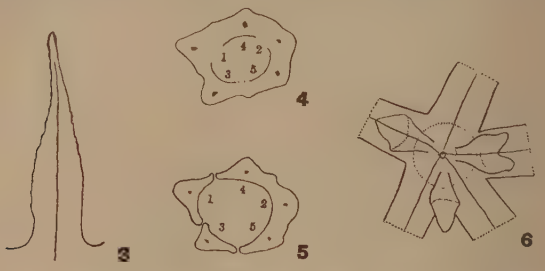

FIGS. 1 and 2.—*Asterolinum stellatum*. 1. Sepal with midrib and two pairs of lateral veins, but without commissural marginal veins. 2. Corolla with the superposed staminal filaments from which the anthers have been removed. The filaments spring from the petals at the level of the ' shelf ' or ring of thickening which occurs at the top of the short tube. The vascular system consists of ten cords ; five on the sepal radii which fork below the level of separation of the petal lobes and provide a marginal system for the petal on each side ; five on the petal radii which furnish a petal midrib and a bundle (not shown) for the superposed (antepetalous) stamen. [The middle region of the petal midribs is not visible owing to the thickness of the staminal filaments which overlie them.]

fertile, G5+5, i.e. G5, sterile, forming the ovary wall, style and stigma, +5 (or fewer) forming the ovuliferous column. Ovules numerous. Fruit dehiscing along the lines of the 5 sterile carpel midribs into 5 valves.

*Calyx* very slightly zygomorphic, gamosepalous at the base. Sepals quincuncially arranged, lanceolate, about one-third as long again as those of *Pelletiera*. Sepal 4 posterior. Sepal midribs with 1, 1½, or 2 pairs of lateral branches in the lower

half (fig. 1). *Corolla* gamopetalous, actinomorphic, rotate, with a short tube. Petals all alike and all alternating with the sepals, the free limb of each petal broader than it is long, with rounded apex and entire margin (fig. 2). Fertile *stamens* all similar in size and shape, antepetalous, one being seated in the mid-line of each petal.

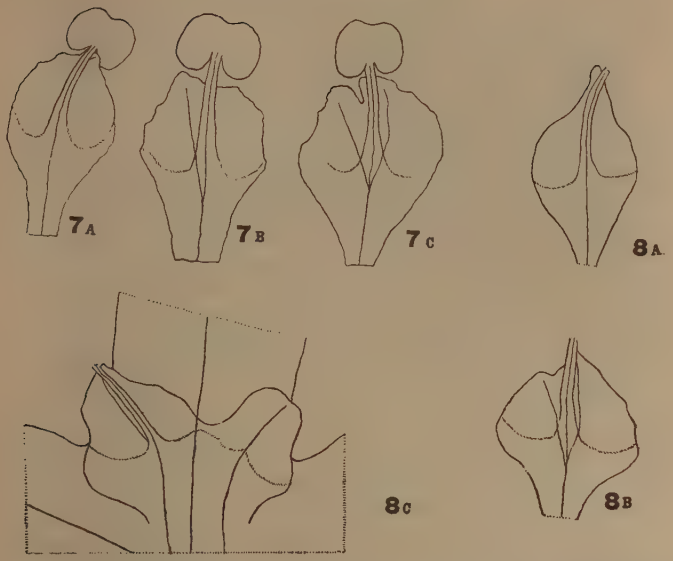
Pelletiera verna A. St. Hil.—K5, C appearing to be 3 or very rarely 4, A 3 or rarely 4, epipetalous, fertile, G 3, sterile, forming the ovary wall, style and stigma +3, fertile.




Figs. 3–6.—*Pelletiera verna*. 3. Sepal with unbranched midrib and without commissural marginal veins. 4. The gamosepalous base of the calyx in transverse section showing the midrib bundles of the five sepals (numbered in the order of their development). The position of the three corolla segments (one between the two antero-lateral sepals and two superposed, respectively, on the two postero-lateral sepals) is indicated by the exsertion scars (shown as dotted arcs in the inner outline). 5. The same at a slightly higher level, two of the sepals being now free. 6. The gamosepalous base of the calyx, from which the distal portions of the sepals have been cut away, and the three corolla segments as seen *in situ* in a preparation which has been rendered transparent. The simplex (small, anterior) segment alternates with the antero-lateral sepals. The two duplex segments are superposed, respectively, on the two postero-lateral sepals, the larger one being bilobed at the apex, the smaller entire. The three stamens carried by the segments are not shown, and of the vascular system only the midribs of the sepals and the residual central complex are represented. The interrupted ring in the centre defines the boundary of the pedicel which is seen through the tissue of the gamosepalous base of the calyx.

forming the ovuliferous column. Ovules 2. Fruit dehiscing along the lines of the sterile carpel midribs into 3 (or 2) valves.

*Calyx* slightly zygomorphic, gamosepalous at the base (figs. 4–6). Sepals quincuncially arranged, lanceolate about one-third shorter than those of *Asterolinum*. Sepal 4 posterior (figs. 4, 5, 14). Sepal midribs with a lateral on one or on both sides in the middle region, or unbranched (fig. 3). *Corolla* partly polypetalous partly gamopetalous, almost always




FIGS. 7 and 8.—*Pelletiera verna*. 7 A, B, C. The three corolla segments each carrying a median stamen, from a flower of the commonest grade. A. The simplex segment, a single petal, carrying a single antepetalous stamen, with one entering trunk cord which furnishes the bundle of the stamen and the petal midrib (only seen at the tip of the petal where it is not hidden by the overlying staminal filament). B. The smaller duplex segment representing two conjoined petals carrying a median (i.e. intervening) and hence antesepalous stamen, with one entering trunk cord which furnishes the bundle of the stamen and the midrib of the left petal, a midrib for the right petal not being developed. C. The larger duplex segment with slightly bifid apex representing two conjoined petals which have become separate at the tips, an intervening antesepalous stamen, and one entering trunk cord which gives rise to a midrib for each petal and an intervening bundle for the stamen. 8 A, B, C from another flower. A, B. Two corolla segments, each carrying one stamen from which the anther has been removed. A. The simplex segment similar to that shown in fig. 7 A. B. The smaller duplex segment with one entering trunk cord which has given rise to a median bundle for the intervening antesepalous stamen and midrib bundles for the two slightly unequal petals. C. The larger duplex segment carrying one lateral stamen, together with portions of the postero-lateral sepal upon which it is superposed and of the sepal on each side. The segment base is so wide as to bestride the whole width of the underlying sepal. It receives two trunk cords, one proper to the neighbouring petal radius on each side. The one (left) gives rise to a midrib for the corresponding petal and a bundle for the superposed (antepetalous) stamen, from which the anther has been removed, the other (right) only to the corresponding petal midrib.

asymmetrical and consisting of 3 separate segments (fig. 6), very rarely of 4 separate segments and then zygomorphic. Segments always of two kinds :—

i. Segments generally 3, one alternating with the sepals, anterior, smaller and narrower than the other two, longer than broad, conical above the 'waist' (level at which the epipetalous stamen becomes free), the margin entire or slightly waved in the upper half (figs. 6, 7 A, 8 A, 9 A) ; two superposed upon the two postero-lateral sepals (sepals 1 and 2), both larger and broader than the preceding but the one larger than the other (figs. 6, 7 B, 7 C, 8 B, 8 C, 9 B, 9 C) *. The larger of these two segments generally notched at the apex (fig. 7 C) or more or less deeply bilobed (figs. 6, 8 C, 9 C, 10–13), the smaller segment with margin entire or slightly wavy in the upper half, but differing from the small alternating segment in being asymmetrical (figs. 7 B, 8 B), with a retuse or symmetrical apex (fig. 9 B).

ii. Segments rarely 4, three alternating with the sepals, small, similar in size and form to the single alternating segment in the flower with only 3 segments, one superposed on a sepal, similar in size and form to one of the two superposed segments in the flower with 3 segments †.

Fertile *stamens* all similar in size and shape, those borne by the different segments being indistinguishable from one another :—

i. When 3 and associated with 3 corolla segments, one sometimes seated in the mid-line of each segment (figs. 7 A, 7 B, 7 C); or the one carried by the largest segment, if this segment is bilobed, may be seated in the mid-line of either lobe (fig. 8 C), while the two borne by the two other segments are seated in the mid-line of each segment (figs. 8 A, 8 B).

ii. When 4 and associated with 3 corolla segments, two are carried by the larger bilobed segment, one in the mid-line of each lobe (fig. 9 C), the other two being carried in the mid-line of each of the two smaller segments (figs. 9 A, 9 B).

* It seems reasonable to conclude that the difference in size between the two duplex segments is due to unequal conditions set up in the corresponding sectors resulting from the difference in time of development of the sepals upon which the segments are superposed (see fig. 14 and later p. 107).

† Since this large segment is represented in Baillon's figure (loc. cit., p. 321, fig. 376), as bilobed it would appear to correspond with the larger of the two large ones present in the flower with three segments. This evidence cannot, however, be accepted without confirmation, not only because it implies the less likely alternative, but also because in the figure 375 of the flower with three segments the artist has represented *both* of the large segments as bilobed and similar, a condition I have never observed and one which is contrary to expectation.

iii. When 4 and associated with 4 corolla segments, of which one is large and antesepalous, two stamens are carried by this antesepalous segment, one by each half of the segment, and one is seated in the mid-line of each of the other three segments which are uniform in size and shape and alternate with the sepals.

The above variations in floral construction in *P. verna* establish two fundamental facts which, as shown below, are entirely confirmed by the vascular scheme, viz. (1) that C 3 and C 4 are not correct descriptions of the corolla and

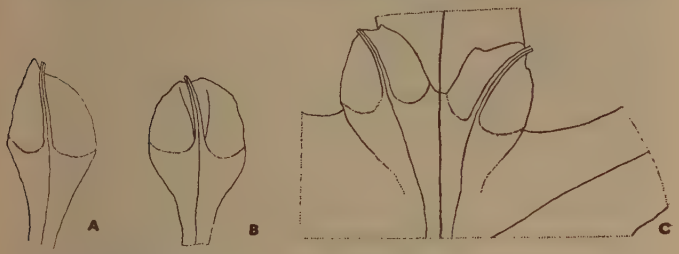



FIG. 9.—*Pelletiera verna*. 9 A, B, C from another flower. A, B. Two corolla segments each carrying a median stamen from which the anther has been removed. A. The simplex segment similar to those shown in figs. 7 A and 8 A. The petal midrib bundle is completely hidden by the overlying staminal filament. B. The smaller duplex segment with one entering trunk cord which has given rise to the two petal midrib bundles (the lower portion of these bundles being hidden by the overlying staminal filament) and to a bundle for the intervening antesepalous stamen. C. The larger duplex segment carrying two lateral stamens from which the anthers have been removed together with portions of the postero-lateral sepal upon which it is superposed and of the sepal on each side. The segment is deeply bilobed above, and below is so wide that, as in the corresponding segment shown in fig. 8 C, its base bestrides the width of the underlying sepal. Two separate trunk cords lying on the neighbouring petal radius on each side enter the segment. Each gives rise to a bundle for the corresponding antepetalous stamen and (doubtless) to a midrib bundle for the underlying petal, but these midribs are completely hidden by the overlying filaments.

(2) that the reduced fertile androecium consists of a mixture of members of the antesepalous and antepetalous whorls. Both the corolla and the androecium are, in fact, unique among Primulaceae.

The main features of the corolla result from the manner in which the trend towards zygomorphism, which has already become expressed in some measure in the calyx, has been met under (presumably) certain unequal radial conditions consequent upon the quincuncial development of the sepals. This further modification has been brought about, not by the

suppression of individual petals, but by a process of partial, and at the same time balanced, disjunction of the complete corolla whorl which results ordinarily in the formation of 3 separate segments all of different sizes, the difference between the two paired segments which lie on the postero-lateral radii being due in all probability to the development *in succession* of sepals 1 and 2 upon which these segments are superposed, and to different spatial conditions which consequently arise on these radii. The unpaired segment, i.e. the one segment consisting of a single petal, is anterior. It is developed on the radius on which there is, presumably, most space; for in Primulaceae the disposition of the sepals is such that it is the overlapping edge of sepal 3 which lies in the mid-line in front. Now in the quincuncially arranged calyx sepals 3, 4 and 5 generally completely surround the inner whorls so that after both edges of sepals 1 and 2 have become free, or, where sepal 1 is fused on one edge with sepal 4 and sepal 2 similarly with sepal 5, after both sepals have become free on their other edge the edge of the three inner sepals surrounding the corolla which is freest to yield to pressure from the developing petals is the overlapping edge of sepal 3. Lack of space between the two lateral petals on either side of the flower has resulted in *Pelletiera* in the fusion of each pair into a single structure, the duplex segment. A similar twofold result, viz. the fusion of four out of the five members of a whorl in two pairs and the differential size effect on the two structures resulting from the fusions, both features undoubtedly due to the quincuncial order of development of the sepals, is to be seen in the androecium of species of *Hypericum* in which the original (ancestral) actinomorphic arrangement of five equivalent antepetalous groups of stamens has given place, in those forms in which the ground space is restricted, to the formation of three non-equivalent staminal groups, one corresponding to a single staminal member (simplex), antepetalous, consisting of a small number of stamens, two representing two neighbouring and fused staminal members (duplex), the one larger than the other, but both ordinarily consisting of more stamens than the simplex group and both antesepalous (E. R. Saunders, 'On Rhythmic Development and Radial Organisation in the Flower', Journ. Linn. Soc. Lond., Bot. L., pp. 313–321 : 1936).

Response in the androecium of *Pelletiera* to the conditions existing in the corolla has, on the other hand, resulted in the suppression of some members of the antepetalous whorl in adjustment to the development of some members of the antesepalous whorl. This adjustment has not yet reached the same degree of stability as the modification in the scheme of the corolla and is still in process of taking place. Some

of this variability is again no doubt indirectly attributable to the quincuncial arrangement of the sepals, for all the stamens spring from the corolla segments and any inequality in vigour of development induced by this arrangement in these segments is likely to be reflected in the development of the staminal members which they carry.

Notwithstanding the difficulties involved in the conception that the three separate segments of the corolla represent three individual petals this interpretation has been accepted hitherto without question, even in face of the crucial fact, never definitely stated, it is true, but easily observed on inspection, that two of these segments are invariably superposed on a sepal. The only writer to make any comment on this C 3 A 3 ground-plan appears to have been Eichler, who, when dealing with the subject of the arrangement of floral members in the general Introduction to his 'Blüthen-diagramme', remarks that typical oligomerous corollas are unknown to him, and adds in a footnote that whether K 5 C 3 A 3 is a correct rendering for *Pelletiera* he is not able to state, as only the brief description of the plant is known to him (Blüthendiagramme, I, p. 10, footnote **: 1875). He evidently considered the combination K 5 C 3 sufficiently unusual to arouse doubt. With this exception the appearances seem to have been universally accepted at their face value.

As regards the differences in size and shape of the three corolla segments in the individual flower it seems clear that the constancy of this feature escaped the notice of the early observers, for St. Hilaire and de Girard remark (loc. cit.), as though the circumstances were exceptional, that Decaisne found two flowers with bifid petals in Commerson's specimens. And of the two figures which the above-mentioned writers give of individual petal segments one obviously depicts the smallest alternating type of segment and is described as normal, the other, equally obviously representing one of the two larger segments, is described as the abnormal type of petal seen by Decaisne.

The constant superposition of two of these three segments upon sepals also seems to have passed completely unnoticed. This relation can, however, be traced in one of Baillon's two figures of the whole flower (loc. cit., fig. 375), but the scale of the illustration is so small that it is hardly likely that this fact would be appreciated by a reader who was not already aware of this highly exceptional arrangement and who examined the figure closely for the purpose of seeing whether the artist had drawn it correctly. For there is no reference in the text to this apparent anomaly. The petals are merely described as either bifid or entire, but without indication of the regular incidence of the two forms.

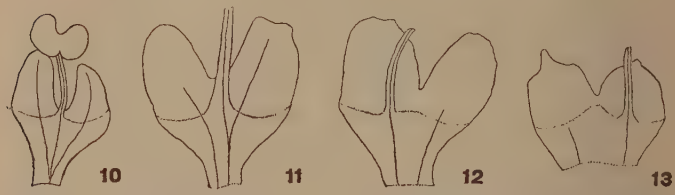
The fact that St Hilaire and de Girard regarded and described the lobed corolla segments as abnormal had an unfortunate result. For although their figure of this form is reproduced in the account in ' Flora Brasiliensis ' (loc. cit.), it does not appear either in Engler's ' Pflanzenfamilien ' or in the ' Pflanzenreich '; hence in these latest accounts this vital clue to a correct interpretation is no longer before the reader.

The true construction scheme of the corolla has now to be made clear. As stated above, the zygomorphic trend common to both *Asterolinum* and *Pelletiera* in the calyx manifests itself in *Pelletiera* also in the corolla, which has besides become polypetalous. This twofold modification has been brought about in the commonest form (hitherto described as C 3), not, as has been supposed, by the suppression of two petals and the complete separation of the remaining three, but by a zygomorphically symmetric process of partial polypetaly in the complete corolla. The five petals are, as previously stated, all present. The anterior member of the five is completely disjoined from its neighbours and appears as the small (simplex) segment intervening between the two antero-lateral sepals. The antero-lateral and postero-lateral petals on each side have remained partially united in the large bilobed segment and completely united in the smaller entire segment. Consequently these two large (duplex) segments are superposed on the two postero-lateral sepals, for each is formed of the undisjoined petals proper to the neighbouring radius on each side. The rare floral type with four segments (hitherto described as C 4) did not occur in my limited supply of material, but it is evident from the above account and from Baillon's figure that in this, as in the common type, all five petals are present, but that disjunction has been carried one stage further, being now complete on four radii instead of three, so that only one superposed (duplex) segment is formed; the other three segments consist of single petals and therefore alternate with the sepals.

The varying degree of disjunction of the petals in the duplex segments is associated with corresponding variations in vascular development. In *Asterolinum*, as in other isomerous pentamerous types in the Family, the vascular supply of the perianth and androecium is derived from ten trunk cords, five arising and running outwards on the sepal radii and five on the petal radii. The five cords on the sepal radii furnish the sepal midribs and the persisting bundles proper to the ' lost ' antesepalous staminal members which run upwards in the corolla tube. When these staminal members undergo sterile modification, such as has occurred in all other genera in the Family, these bundles fork at the top of the corolla tube, each branch entering the limb of the adjacent petal on

the corresponding side, where it gives rise to a separate marginal venation system. There is no prolongation of these cords in the mid-line above the level of the fork unless some degree of separate morphological form is still attained by these sterilized members of the androecium such as is still to be found in *Samolus*, where the cords are continued into antherless filaments. The five antepetalous cords similarly furnish the petal midribs and the bundles for the antepetalous fertile stamens which are seated over the petal midribs. The whole scheme is actinomorphic in accord with the floral symmetry, and constant for each type. In *Pelletiera* vascular development is less regular and shows some variation going hand in hand with the variations in size and form of the corolla segments. The alternating anterior simplex segment of the 'C 3' flower, which always carries a single median stamen, always receives a single median trunk cord (figs. 7 A, 8 A, 9 A). This cord turns out from the central cylinder on the corresponding petal radius and eventually furnishes the petal midrib and the staminal bundle. The smaller of the two duplex segments also carries a single median stamen and receives a single median cord (figs. 7 B, 8 B, 9 B). But this cord originates in the centre from the same vascular complex or unit as the midrib bundle of the sepal upon which the segment is superposed. It runs outwards on the corresponding sepal radius and, as in the case of the simplex segment, supplies both segment and stamen. Now this segment consists of two conjoined petals. When it attains its fullest development the entering cord breaks up into three bundles, two lateral which become the midrib bundles of the two petals, and one median prolonged in the line of the entering cord and serving the stamen (figs. 8 B, 9 B). When development is less vigorous the break-up yields only a lateral on the one side for the corresponding petal in addition to the staminal bundle, the other half of the segment (i.e. the other petal) being without a vascular bundle (fig. 7 B). The larger of the two duplex segments, which similarly consists of two petals, sometimes carries a single stamen which may then be median (figs. 7 C, 10) or lateral (figs. 8 C, 12, 13) (i.e. seated either in the mid-line of the whole segment or of one of the component petals), sometimes two which are then both lateral (fig. 9 C). In the large duplex segment *with a single median stamen* the vascular scheme is almost always similar to that of the smaller duplex segment. A single trunk cord turning outwards on the radius of the sepal upon which the segment is superposed gives rise, after entering the segment to a median bundle which serves the stamen and to a petal midrib on the one side only or on both sides. Very rarely such a segment receives two separate cords, one nearly median the other distinctly lateral (fig. 11).

The nearly median cord breaks up into a median bundle which enters the stamen and a lateral bundle which becomes a petal midrib ; the original lateral cord continues upwards entire as the midrib of the other petal. The segment *carrying one or two lateral stamens* (i.e. stamens seated in the mid-line of one or or both component petals) always receives two cords (figs. 8 c, 9 c, 11, 12, 13). These cords run outwards from the axis centre, not on the radius of the sepal upon which the segment is superposed, but on each side of that radius; in other words, on the neighbouring petal radius on each side. Both give rise to a petal midrib and a stamen bundle when two lateral stamens are carried ; one to a petal midrib and stamen bundle, the other only to a petal midrib when only one lateral stamen is developed.




FIGS. 10–13.—*Pelletiera verna.* The larger duplex corolla segment from four different flowers. 10. A deeply bilobed segment carrying a median (antesepalous) stamen, with one entering trunk cord which gives rise to a midrib bundle for each petal and an intervening staminal bundle. 11. A deeply bilobed segment carrying a median stamen with two entering trunk cords, the one, lateral, giving rise only to a petal midrib, the other almost median, to a petal midrib and a bundle for the intervening antesepalous stamen. 12. A deeply bilobed segment carrying one lateral stamen, with two entering trunk cords, one giving rise only to a short petal midrib, the other to a bundle for the lateral (antepetalous) stamen and (probably) a short petal midrib hidden behind the filament. 13. A segment rather less deeply bilobed, but otherwise similar to the segment shown in fig. 12. (The anthers have been removed in figs. 11, 12, and 13.)

The facts then are that in the simplex segment there is always a midrib bundle in the mid-line of the whole segment after the break-up of the entering cord, whereas in the duplex segments this is never the case. In the duplex segments, whether one midrib is present or two, these bundles run in the mid-line, in the former case of one half, in the latter of both halves of the segment. This vascular scheme is in entire accord with the development of the simplex segment from a single petal and of the duplex segments from two petals. Modification of this basic scheme occurs either owing to unequal development of the two halves of a duplex segment (i.e. of the two component petals), or to variations in the process of 'condensation'

whereby the antero-lateral and the postero-lateral petal cords on the same side of the corolla become approximated to the radius of the intervening sepal midrib, and in the extreme case become completely fused, giving rise to a single compound cord superposed on the intervening sepal midrib. If development is sufficiently vigorous this compound cord becomes resolved in its further course into its constituent units. That resolution of such synthesized cords should sometimes be complete (as when such a compound median cord gives rise to two petal midribs and an intervening stamen bundle) and sometimes incomplete (as when only one petal midrib is developed in addition to the stamen bundle) is merely indicative of the condition of instability which is commonly characteristic of the process of transition from the stable level represented by the full ancestral ground-plan to some new level of stability lower in the scale of development.

The same kind of instability associated with vascular 'condensation' is met with in *Veronica*, where fusion of the

FIG. 14.—Floral diagram of an isomerous primulaceous type showing the form of quincuncial arrangement in which sepals 1 and 2 are postero-lateral.

two postero-lateral petals into a single posterior segment is accompanied by a similar approximation of the two postero-lateral petal midribs until in the last stage they are fused into a single bundle (E. R. Saunders, 'A Study of *Veronica* from the Viewpoint of certain Floral Characters', in Journ. Linn. Soc. Lond., Bot. XLIX, pp. 453–493 : 1934). In these *Veronica* forms, however, the intervening sepal together with its midrib bundle has already been lost, and when a single bundle takes the place of the two petal midribs the fusion is permanent, the synthesized segment remains entire, and the single bundle remains unresolved throughout its course. But whereas in *Pelletiera* every grade in the scale is found in the one species and even in the individual, in *Veronica* the whole range of grades is not to be found within the single species.

It remains to consider the unique features of the *Pelletiera* androecium. The single median stamen carried by the simplex segment and the lateral stamens, whether one or two, carried by the larger duplex segment obviously belong to the

antepetalous whorl. They are seated over the midrib of the petals which carry them, and staminal bundle and petal midrib are furnished by the break-up of a common trunk cord developed on the corresponding petal radius. In those duplex segments carrying a single stamen in the mid-line of the segment this stamen is not seated in the mid-line of an individual petal, but on the line of junction of the two petals composing the segment, i.e. such stamens lie on a sepal radius. The vascular bundle which they receive is the direct prolongation of the compound trunk cord arising on the radius of the sepal upon which the segment is superposed. This cord represents a middle component proper to this sepal radius fused with that belonging to the petal radius on each side. When the break-up into these three components takes place it is the middle bundle which enters the stamen. It is thus obvious that the single median stamen carried by a duplex segment belongs to the antesepalous whorl. Here then we have an androecium unique among Primulaceae (E. R. Saunders, ' On Carpel Polymorphism, V., in Annals of Botany, XLVI, pp. 260–87 : 1932) in that it is made up of some members of each whorl, one or two antesepalous members being present together with one, two, or rarely three antepetalous members, each antesepalous member having replaced two members of the antepetalous whorl, so that not more than a total of four members is ever developed and generally only three. Hitherto a primulaceous type in which any members of the antesepalous staminal whorl have remained unmodified and fertile has been unknown.

Now, although it is characteristic of the vascular bundle of the cylindrical staminal filament to remain unbranched, it is no less typical of these bundles when well developed to give rise to a branch system if the filaments assume dorsiventral form, as they do normally in *Platycodon grandiflorum* (see E. R. Saunders, ' Floral Morphology, A new Outlook ', II, p. 499 : 1939), and as they may do occasionally in exceptional flowers of *Veronica* (E. R. Saunders, ' Comments on " Floral Anatomy and its morphological Interpretation ', in The New Phytologist, XXXIII, p. 156, figs. 45–49 : 1934). This branching becomes still more pronounced when loss of function is accompanied by incorporation into the corolla, as happens in most Primulaceae.

Similar persistence of staminal bundles and development of branch systems after loss of function followed by loss of separate form occurs in those flowers of species of *Salvia* in which the two postero-lateral staminodes no longer attain separate morphological form (loc. cit. p. 144, fig. 21). *Salvia* is, indeed, of special interest in this connexion. As, however, it is proposed to treat the additional evidence from this genus in a separate communication, it may suffice to state here

that, just as the new evidence obtained from *Pelletiera* adds to the already large body of evidence controverting Dr. A. Arber's statements that there is no reason to regard the bundles present on the sepal radii, which in the gamopetalous primulaceous corolla run up the tube and into the neighbouring petal lobes, as the bundles of a lost antesepalous staminal whorl, and (2) that belief in vascular survival has been responsible for an artificial and erroneous interpretation of the primulaceous androecium ('Floral Anatomy and its morphological Interpretation', The New Phytologist, XXXII, p. 128: 1933), so the earlier generalization of Grélot that when there is complete abortion the vascular bundles never persist ('Recherches sur le système libéroligneux floral des gamopétales bicarpellées', in Ann. Sci. nat., sér. VIII, 5, p. 150: 1897) is refuted not only by the evidence from mature flowers of *Salvia Schiedeana* which I have previously brought forward (E. R. Saunders in The New Phytologist, XXXII, loc. cit.), but also by that obtained from species of this genus in an earlier stage of development. It is hoped to publish this further evidence shortly.

## Summary and Conclusions.

1. The flower of *Pelletiera verna*, a monotypic genus of Primulaceae, is described and compared with that of its nearest ally, *Asterolinum stellatum*.

2. It is shown that the construction of the corolla and androecium in *Pelletiera* has never been correctly apprehended and that it is unique among Primulaceae.

3. The unique feature of the corolla consists in a regular combination of complete polypetaly on some radii with retention of the gamopetalous condition on other radii. This results in the formation almost always of 3, very rarely of 4, separate segments of dissimilar form. In the former case the corolla is asymmetric, in the latter zygomorphic.

4. The hitherto unquestioned assumption that these individual segments correspond with individual petals is shown to be erroneous, the full complement of five petals being present in all flowers.

5. In the asymmetric corolla of 3 segments all three segments differ from one another in size and shape. One, formed of the anterior petal (simplex), is small. The other two, which are both larger, consist of an antero-lateral petal fused with the postero-lateral petal on the same side (duplex). The difference in size and form between these two larger segments is attributed to differences in the spatial conditions on the two corresponding radii resulting from the quincuncial arrangement of the sepals.

6. In the corolla of 4 segments three consist of similar single petals (simplex) and one of two conjoined petals (duplex).

7. The androecium consists of 3 or rarely of 4 stamens all similar and functional. It differs from that of every other primulaceous type in that it is composed of some members of both whorls, being expressed as $A_{2+1}$ or $A_{1+2}$ in three-stamened flowers and as $A_{1+3}$ in four-stamened flowers.

8. The vascular scheme affords complete confirmation of the ground-plan of the corolla and androecium as described above.

9. The facts here summarized establish that the antesepalous vascular bundle, which in *Pelletiera* always runs in the mid-line of the smaller duplex corolla segment, and sometimes of the larger duplex segment as well, conjoined with the two midrib bundles (when present) belonging to the adjacent petal on each side and which, when disjoined from these bundles, is continued into the filament of the superposed stamen, corresponds with the antesepalous vascular bundle in other Primulaceae which, having become detached from a trunk cord which also furnishes a sepal midrib, runs up in the corolla tube on the corresponding sepal radius. The chain of evidence proving that these bundles are the bundles proper to the antesepalous whorl of stamens is thus complete.

10. The evidence for the conclusions reached regarding the vascular ground-plan of the androecium in Primulaceae finds a parallel in the vascular scheme of *Salvia* among Labiatae.

*Discussion.*—

Mr. J. S. L. Gilmour asked Miss Saunders if there was any evidence as to how the number of stamens had become reduced from the normal five to three or four.

Dr. L. Richmond Wheeler enquired if the number of stamens was always three in this interesting flower. He understood that the five petals of ordinary Primulaceae were traceable in the three of *Pelletiera* and wondered if vestiges of the two aborted stamens ever occurred.

Replying to a question by Mr. Gilmour Miss Saunders said that each of the three (or four) segments into which the corolla in *Pelletiera* was divided bears a single stamen. In one flower among all those which she had examined the large segment had been so deeply lobed as to be almost divided in two and this segment bore two stamens, one in the mid-line of each half, but this condition was undoubtedly of rare occurrence.

Sir Arthur W. Hill and the President also spoke.

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[Part 1, pp. 1–110, *published* 9 *February* 1940.]

**NOTICE**

Attention is called to a Standing Order of Council relating to Papers,—

'In the Journal or Proceedings of the Linnean Society except by special resolution of the Council not more than one paper shall be published by any one author not being a Fellow of the Society.'